HOW 'SPOOKY' CHANGED THE WAR IN VIETNAM

AIR&SPACE

Smithsonian

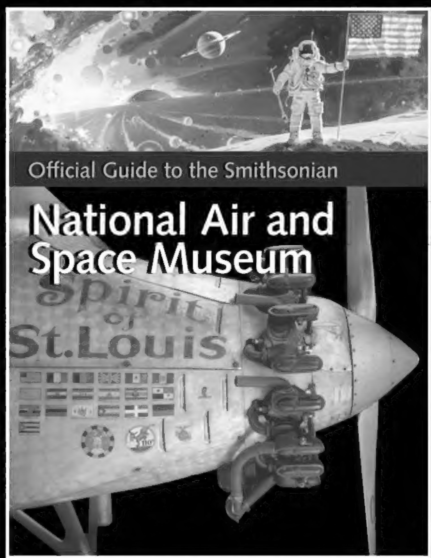
JULY 2002

Remember your first time?

FAMOUS FLIERS REMEMBER THEIRS

PAGE 44

WHAT WENT WRONG ON FLIGHT 427



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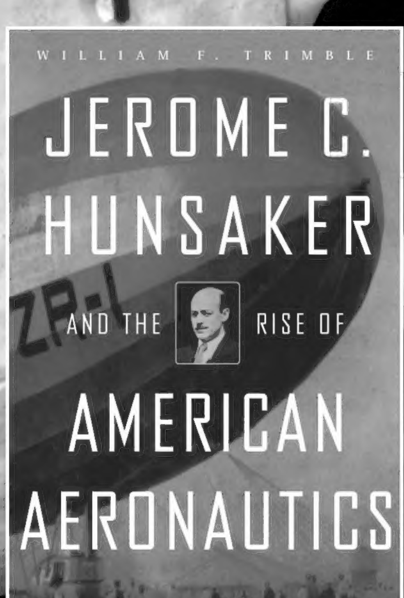

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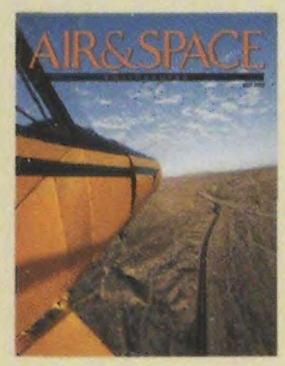
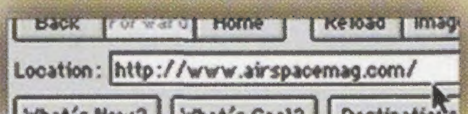
June/July 2002
Volume 17 • Number 2

FEATURES



Cover: Warning! Gazing too long at Russell Munson's photograph of his Super Cub on the wing may induce a desire to take the afternoon off and head for the airport. (Have fun.)

DEPARTMENTS



Halfway to Anywhere

A new IMAX film showing at the National Air and Space Museum documents the construction of the International Space Station. Narrated by actor Tom Cruise, *Space Station* stars the astronauts, engineers, and technicians who have been building the station 250 miles above Earth. This powerful film, photographed and presented in 3-D, fills us with awe and the wonder of discovery, while it demonstrates why we must move on to a continuous human presence in space. And it shows us how the ISS is the first step in that critical process.

The space station has been a central goal of the spacefaring community in the United States since the origin of the space program. We understand that reaching orbit is the hard part, that once a rocket overcomes Earth's gravity, travelers are "halfway to anywhere" they want to go. At that halfway point, space stations serve as the transit platform for vehicles traveling between Earth and the moon—and beyond.

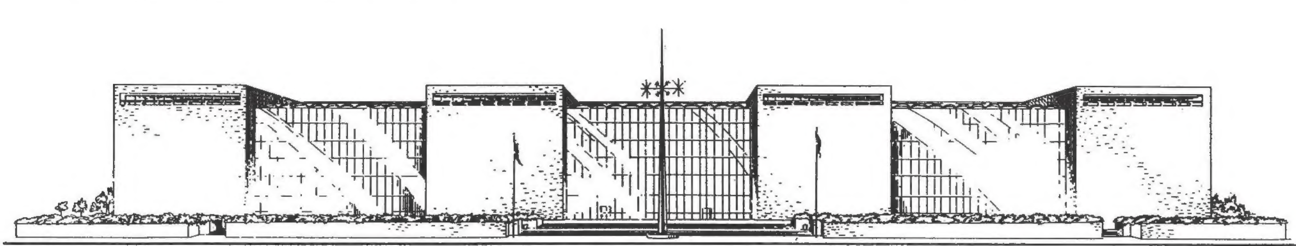
In this context, a space station was always envisioned as a base camp for further space exploration. It has been touted by early visionaries such as Konstantin Tsiolkovsky, Hermann Noordung, and Wernher von Braun, as well as by all recent advocates of humanity's movement into space. This idea persists from the dreams of those early space pioneers through technical studies of the 1960s, the operation of Skylab in the 1970s, President Ronald Reagan's approval of a full-fledged space station in 1984, the station design called Freedom (1984 to 1993), the shuttle-Mir docking missions of the 1990s, and the construction of what we now refer to as the International Space Station.

In 1998 the first elements of the ISS were assembled in orbit, and a succession of missions since that time has sustained the impressive effort to construct an orbital space station. In 2000 the first crew took up residence aboard the craft, and from that point on, the space-faring nations of the world intend that no future generation will ever know a time when there is not a human presence in space. The ISS promises to become the anchor tenant of a research park in space, contributing knowledge necessary to make life on Earth more rewarding and to aid humanity's movement beyond this planet. Like the base camp at the foot of Mount Everest, the ISS will ultimately serve as the jumping-off point for exploration beyond Earth orbit.

It is an idea with a long history in literature and art. More recently, the image of a space station floating above Earth has appeared in science fiction films ranging from *2001: A Space Odyssey* to *Mission to Mars* and in television productions such as the Star Trek series. The image has sometimes been presented as an extravagant way-station to the planets. Sometimes it's depicted as an austere research outpost with teams of scientists seeking to learn more about our universe.

At the beginning of the new millennium, the United States and the former Soviet Union have joined 14 other nations to make the long-held vision of a space station in Earth orbit a reality, and for the first time, we are seeing a film about the real thing.

—J.R. Dailey is the director of the National Air and Space Museum.



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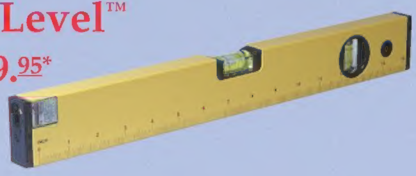

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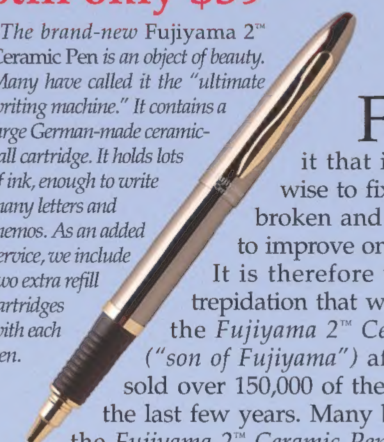
•*The optics of* Admiral Nelson's Telescope™ *are "25x30" which means 25x magnification and the great light gathering capacity of a 30-mm objective lens. Admiral Nelson's telescope was made of brass. This replica is heavily chrome-plated for extra beauty and protection. The scope comes with a belt-looped vinyl carrying case. For permanent mounting, the scope comes with an extendible table -top tripod.*

Does this Japanese model outperform famous European luxury pens?

Fujiyama 2™ Ceramic Pen still only $39.95*



•*The brand-new* Fujiyama 2™ Ceramic Pen *is an object of beauty. Many have called it the "ultimate writing machine." It contains a large German-made ceramic-ball cartridge. It holds lots of ink, enough to write many letters and memos. As an added service, we include two extra refill cartridges with each pen.*

Folk wisdom has it that it's seldom wise to fix what isn't broken and to attempt to improve on perfection. It is therefore with some trepidation that we introduce the *Fujiyama 2™ Ceramic Pen*, *("son of Fujiyama")* after having sold over 150,000 of the original in the last few years. Many believe that the *Fujiyama 2™ Ceramic Pen*—made in Asia and with a cartridge that is the finest product of German stationery technology—is the most handsome and best-writing pen in the world. *Fujiyama 2™* has stunning hi-lacquer gunmetal finish, fine gold-plated accents and snappy clip. It has perfect heft and feel and, of course, just like its predecessor, it writes like a dream. And with its new cushioned Turbogrip™, which lets you write for hours without tiring, this pen has now been brought to the edge of the 21st century. ***Fujiyama 2™ Ceramic Pen.* #1049V577c**

A breakthrough in audio technology…

MR-318T AM/FM/TV Stereo Personal Digital Radio™ only $69.95*

There is absolutely nothing like it. This outstanding personal receiver fits in your shirtpocket or fits inconspicuously on your desk or night table. It's packed with features that give you crisp reception over the entire AM and FM bands and the audio portions of all VHF TV channels—2 to 13. Here are some of the other great features of this breakthrough personal digital radio:

•*The MR-318T works on two AA-batteries (included). It measures only 5 x 2.5 inches and weighs less than six ounces. Fidelity is astonishing, in both loudspeaker and earphone modes! The maker of the MR-318T receiver is one of the world's leaders in the production of advanced radio equipment.*

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- Batteries Included

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Time and date accuracy never to be questioned again…

Atomic Digital Watch™ only $69.95*

Atomic Digital Watch allows you to never have to set the time and date again by automatically tuning in and adjusting itself to the official time transmitter daily through radio frequency. The *Atomic Digital Watch* from LaCross Technology is controlled by a radio signal distributed by the National Institute of Standards and Technology and is the Standard used by the U.S. Naval and Energy Dept. The time is precise to a minuscule fraction of a second. This super-accurate radio controlled watch displays the day and date, indicates level of signal reception and is powered by a 3V long lasting lithium battery. The *Atomic Digital Watch* lets you choose from 24 time zones with special U.S. time zones displayed. Never again adjust for daylight savings time. It automatically does it for you. In addition to its accuracy, the watch is water resistant to 30 meters and has a battery saving "OFF" function. The band is adjustable and has a butterfly clasp for a great fit. Order this as a gift for the precision and technology buff. ***Atomic Digital Watch*™ Item #1102V577e**

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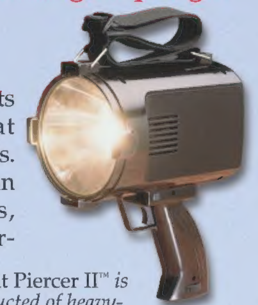

The *Night Piercer II*™ casts a focused beam that can be seen for many miles. It is 20-times brighter than automobile headlights, more luminous than aircraft landing lights. This powerful light is indispensable for tracking and exploring unknown territory and for any contingencies at night, in plane, boat, truck, or car. With its red gel, the *Night Piercer II*™ can be a lifesaver in any emergency. The unit contains two sealed heavy-duty lead-acid batteries and can be recharged either through your household current or through the cigarette lighter socket of your car, RV or boat. Both adapters are included, of course. The *Night Piercer II*™ should be your companion on all your travels. Don't leave home without it—order it today! ***Night Piercer II*™ #1088V577f**

•Night Piercer II™ *is constructed of heavy-duty high-impact polypropylene. It comes with a super-bright 100-watt halogen bulb and red gel for use as warning light. 110-volt and 12-volt rechargers are also included.*

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LETTERS

Block That Opinion

While I am all in favor of researching and testing various systems of projectile interception, I am opposed to spending untold billions to build and maintain a missile "shield" that will offer real security only to the stockholders and employees of the companies that build it, and to the politicians who shamelessly and falsely imply that it will offer total protection to the rest of us ("Block That Nuke," Commentary, Feb./Mar. 2002).

There are so many reasons that any conceivable missile shield will cost far more than it will benefit us. Some major ones are:

Anyone with the capability to build a missile with the range to reach us and the accuracy to hit particular targets can include enough decoys and countermeasures to make any conceivable defense nearly worthless.

Any attacker could launch a salvo of warheads to explode before interception and blind our radars, then follow up quickly with dedicated warheads.

If we did manage to intercept missiles in the boost phase, wouldn't some of the warheads land on our allies? If we intercepted the weapons over our country, radioactive material would rain down on us, and instead of dying in a blinding flash, we would die slowly from radiation poisoning.

The bogeyman of "rogue" nations or terrorists launching intercontinental ballistic missiles at us is almost laughable. Just as Osama bin Laden is not willing to die for his cause, no other leader of a country is going to launch first at the continental United States, knowing that we could identify the launch point and incinerate his country with a retaliatory strike.

Michael Bugg
Clinton, Kentucky

If I wanted polemics, I would subscribe to a more appropriate journal of advocacy, not *Air & Space/Smithsonian*. We do need a serious discussion of the systems effectiveness of a missile defense, but not in your magazine. By publishing this tract, you lend it an intellectual cachet it does not deserve.

The September 11 attacks demonstrated that an essential feature of asymmetrical warfare is the use of elements of an enemy's systems to create cheap, effective weapons. I disagree with Bruce Berkowitz's dismissal of the dangers of "suitcase" nukes. Trucked across our porous borders or shipped through our busy seaports, they are far more likely threats to our nation than warheads on long-range missiles.

Bart Osborne
Palm Desert, California

Illinois, Kid-Built-Aircraft Capital of the World

In response to "Shop Class Was Never Like This" (Apr./May 2002), mine actually was. In the 1950s I attended Champaign High School in Champaign, Illinois, and we had a class taught by an airframe-and-powerplant mechanic named Mr. Herman Linder. We rebuilt an Aeronca and a 1929 Waco glider, and we built two gliders: an all-metal Schweizer 1-26 and an experimental design of Mr. Linder's featured in *Flying* magazine.

Greg Parsons
Denver, Colorado

When Good Barbies Go Bad

I see Homer Hickam is up to his old tricks. I winced when I watched the movie *October Sky* [based on the Hickam memoir *Rocket Boys*] and saw those needle-nosed rockets plummet earthward, and I winced again when I read his article "You Go, Girl!" (Flights & Fancy, Apr./May 2002). The National Association of Rocketry safety code clearly states: "I will use a recovery system such as a streamer or parachute in my rocket so that it returns safely and undamaged and can be flown again…." The model rocket engines Mr. Hickam purchased probably included a copy of that code and were sold with the understanding that the user agrees to adhere to it.

Hickam's childhood exploits can be forgiven, but an adult should not be launching model rockets without a recovery system. Without one, a rocket is not a spacecraft but a missile.

David Allen
Round Rock, Texas

Homer Hickam responds: You can stop wincing. My article did mention my recovery system: His name was Old Joe. And Barbie's bounteous hair was a wonderful speed brake—you could have caught her in your hands. As for the rockets of our youth, read Rocket Boys *and you'll see they were far more sophisticated than those in the movie.*

A Dopey Omission

I want to correct the statement in "Best of Seven" (Restoration, Apr./May 2002)

atomic Digital Technology

Atomic accuracy in any U.S. time zone

Atomic digital watch keeps time and date accuracy by reading from the official time transmitter.

The world has become a smaller place in the past few decades. Transactions take place across the world in an instant. Having a timepiece that can not only keep perfectly accurate time, but keep track of the time zones can be really helpful and convenient. Now there is a watch that can scientifically give you the right time in all zones within the 2,000-mile radio signal range.

If you travel—this watch is a necessity.

The Atomic Digital Watch from LaCrosse Technology is radio-controlled, maintaining its incredible accuracy by automatically reading from the official standard frequency and time transmitter in North America. This WWVB radio signal gets its time from the most precise clock in North America based in Colorado, and transmits its signal over a 2,000-mile range. When outside the range, the timekeeping operates off a 3-volt lithium battery. The Atomic Digital Watch gives you a selection of 24 time zones. This ultra-accurate radio-controlled timepiece has a perpetual day and date calendar, signal reception indicator and is powered by a 3-volt lithium battery expected to last three years.

Radio wave technology

A timely gift.

In addition to its accuracy, the watch is water resistant, and has a battery-saving "OFF" function. The stainless steel butterfly clasp and removable links to adjust the band size make it a good fit. This watch is a great gift for anyone who values precision and technology.

Does anyone really know what time it is?

Well, the U.S. Government wants to, so they created the National Institute of Standards and Technology, a component of the U.S. Department of Commerce. The Time and Frequency Division, located in Boulder, Colorado, maintains the F-1 Fountain Atomic Clock, the nation's standard of time. This clock neither gains nor loses a second in 20 million years. This watch is the next best thing to having your own atomic clock, because it automatically displays the precise accurate time. It sets itself to the F-1 Fountain Atomic Clock using a working battery, it adjusts itself for daylight saving time and leap years, and it features a variety of practical and convenient features to fit your lifestyle.

Try it for yourself.

Advances in electronic technology let you get precise timekeeping at an affordable price. Now, thanks to a factory-direct relationship with the manufacturer of the Atomic Digital Watch, you can try it for yourself with TechnoScout's exclusive home trial. Try this product for 30 days and return it for the full purchase price if not satisfied, less shipping and handling.

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that the B-29 Superfortress named *Doc* is "apparently the only survivor" of a squadron of B-29s based at Griffiss Air Force Base in Rome, New York, and named after the seven dwarfs in the movie *Snow White*. Another survivor is *Dopey*, which since the late 1960s has been at the Pima Air and Space Museum, where I volunteer.

Dopey was originally named *Sentimental Journey* (serial number 44-70016), and was assigned to the 330th Bomb Group out of Guam in 1945. Its origin and history were uncovered in 1980, and the airplane was fully restored to its present excellent display condition (with World War II markings and equipment). The original Guam-based crew has been returning to visit the airplane and is also supporting aircraft restorations through contributions by the 330th Bomb Group.

John Kornfeld
Tucson, Arizona

Still Not Great Enough

Surely "Building a Great Air and Space Library" (Feb./Mar. 2002) could have included at least one classic by Antoine de Saint-Exupéry, whom many regard as the greatest aviation writer; perhaps the wartime memoir *Flight to Arras* or the fictional airmail adventure *Night Flight*. Some of the other omissions I noted were Richard Bach's insightful books, such as *Biplane*; Wolfgang Langewiesche's timeless *Stick and Rudder*, on the art of flying; Paul Brickhill's *Reach for the Sky*, with the memorable story of legless World War II British ace Douglas Bader; and must-have books on airpower, such as Billy Mitchell's *Winged Defense*, H. H. "Hap" Arnold and Ira Eaker's *Winged Warfare*, and Alexander de Seversky's *Air Power: Key to Survival*.

Philip Handleman
Birmingham, Michigan

I was surprised *Sled Driver* wasn't included. Written and photographed by former SR-71 pilot Brian Shul, it includes surreal photos from 80,000 feet and a narrative that gives me goosebumps each time I read it.

Cory Crowell
San Diego, California

Motion Picture Sickness

"Barfology" (Apr./May 2002) reminded me of a problem my father had. He worked tuna boats out of Cape Cod and was never troubled by the roughest seas or the most violent boat motion—as a matter of fact, he rather enjoyed it. If, however, he saw a movie in which the camera showed any boat motion at all, he'd get seasick and have to leave the theater.

Jonathan A. Hayes
Seattle, Washington

One Man's Pig Is Another Man's Eagle

As a missionary in Australia, I was sent to the Royal Australian Air Force base at Townsville, and I could watch the F-111s take off right over the beach and climb out to sea ("The Plane With No Name," Feb./Mar. 2002). I was amazed to see an aircraft that appeared ugly and cumbersome on the ground flying so fast and so gracefully.

Jeff Airth
Fremont, California

"Not Invented Here" Syndrome

I hope that the U.S. Navy F-14 driver who was so willing to reveal his lack of skills in tanking versus the use of what he calls "poorly designed Brit baskets" ("Thanksgiving at Sea," Soundings, Feb./Mar. 2002) will continue to enjoy his carrier's steam catapult, angled flight deck, and optical landing aid. Those features, essential to carrier aviation, are British innovations.

John Joss
Los Altos, California

The Day the Cold War Came to Iowa

On Sunday, September 2, 1962 ("This Is Only a Test," Feb./Mar. 2002), I was spending the afternoon at my father's farm in Iowa. Suddenly we heard a terrific roar outside. We raced out to see at least a half-dozen heavy bombers in a fairly tight formation. An avid airplane nut, I identified the aircraft as B-52s. They were so low—perhaps at 300 feet—that I feared they were going to crash. It was an exciting experience out on the prairie, miles from an Air Force base!

Lowell Andreessen
Reedsburg, Wisconsin

For Further Delights...

Anyone interested in photos of the D.H.89 ("Delightfully de Havilland," Restoration, Feb./Mar. 2002) in service should check out the October 2001 issue (vol. 23, no. 8) of *Scale Aircraft Modelling*.

My only disappointment with your article was the lack of interior photos—the modelmaker's constant lament.

James D. Lawlor
via e-mail

Resisting the Lunar Pull

In the 1970s, my wife Dee and I volunteered as docents at the National Air and Space Museum. We had scores of opportunities to touch the famous moonrock ("The Rock," In the Museum, Feb./Mar. 2002). What started as a dare—"I won't touch it if you won't"—quickly developed into an attempt to be the only two people to *not* touch that piece of the moon, despite repeated opportunities. We still claim this perverse record.

Lt. Cmdr. Dan Coates
U.S. Navy (ret.)
Kukuihaele, Hawaii

Another Aviation Community Heard From

I enjoyed "When Pigs Fly" (Flights & Fancy, Dec. 2001/Jan. 2002), but be advised, real turkeys do fly under their own power (though they aren't graceful and their climb rate is pitiful.)

—Jeff Gorss
Greenfield Center, New York

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"Y'all Are About to Stall"

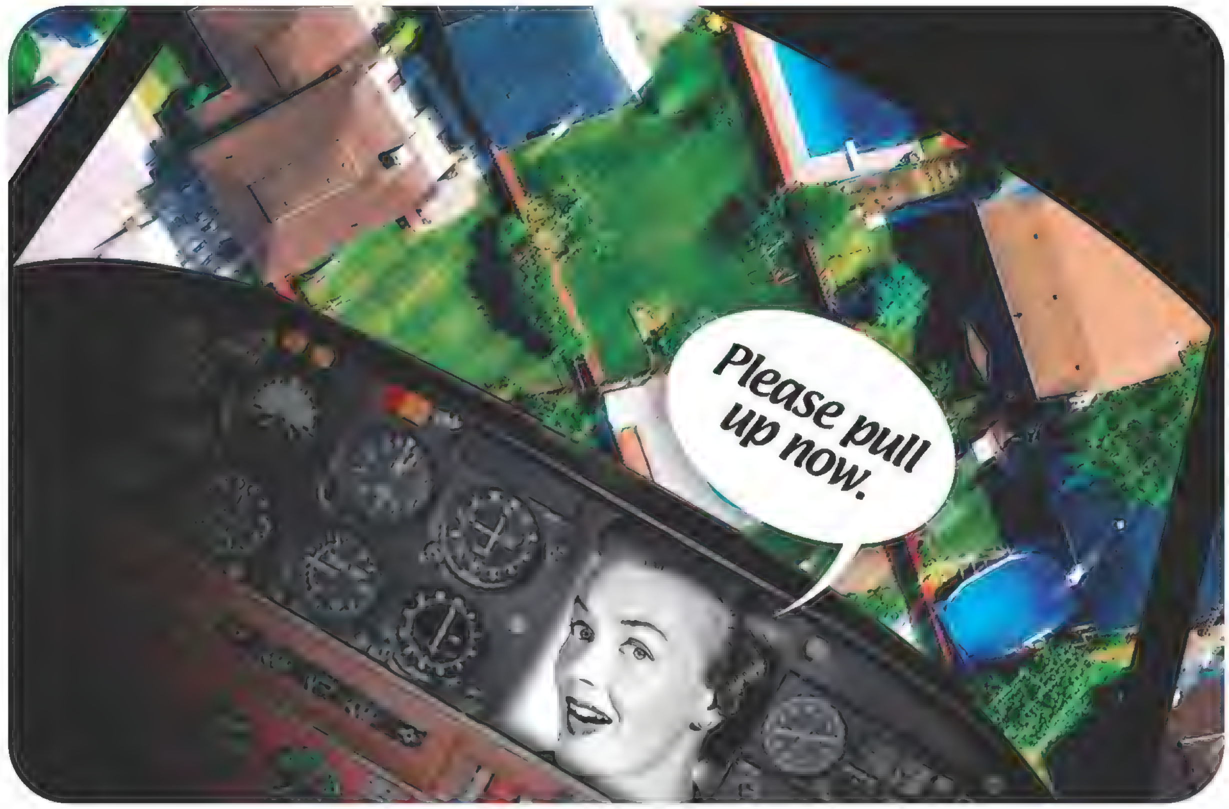
Aircraft designers call the computerized female voice ("Caution! Caution!" "Warning! Warning!") the cockpit communication box, but fighter jocks have another name for it: "Bitchin' Betty." Yet they're usually surprised to hear that Betty's a real live woman. Erica Lane's thick Southern accent betrays her hometown of Huntsville, Alabama. "I can't recall the year," she says. "Maybe it was 10 years ago or more—they requested audition tapes and I sent mine in, and they called me."

SCI Systems, the Huntsville company that built the communication box, asked Lane to sit before a microphone and pronounce "Caution," "Warning," "Engine," "Fire," and other terms. An engineer recorded it, digitized it, and made it "completely and totally different," she says. In other words, you can't tell that Betty—or Lane—has a Southern accent. The engineer had some trouble refining it to that point, however. "Let me tell you how many times I had to say the word 'Fire,'" Lane says. Her accent rendered it more like "Far."

Regardless, she became the voice for the F-16, F/A-18, F-14, and the Apache helicopter—and one other aircraft that the Pentagon has acknowledged but never identified. "The voice is up there in something," she says. She receives no residuals, as actors do whenever their programs are rerun. "I did ask, and they just laughed," Lane says.

There's a good reason Betty is a female voice. Most military pilots and crew members are men, and when something goes wrong in the cockpit, a female voice gets their attention. And maybe the "nag factor," as Lane puts it, helps. With the growing number of female pilots and crew, one day the box may be revoiced as "Bitchin' Bruce," says F-16 pilot Major Brian Wall. Still, some of the guys would miss Betty. "Her 'Caution' is actually kind of sexy," Wall says.

—*Phil Scott*



RANDY MAYS

In a Bind on the Outer Banks

The goofy character on the beverage business' new T-shirt started out posing with likenesses of Wilbur and Orville Wright. Now he's between two generic aviator types.

That's how BrewThru owner Dana Lawrentz decided to avoid trademark infringement fights with the Roger Richman Agency, a California licensing firm that claims rights to the images and names of the Wright brothers.

Many merchants on North Carolina's Outer Banks are preparing for the upcoming 100th anniversary of the Wrights' first powered flight at Kitty Hawk on December 17, 1903, but business owners are thinking twice about selling Wright-embellished items.

Lawrentz says he had okayed the first design last February, before he learned about the agency's pending trademark applications. "They can infer whatever they want—they're two cartoon aviators," Lawrentz says of the new design, which has the cartoon character asking the fliers: "BrewThru—think it'll fly?"

Initially, Lawrentz and others involved in the design had some fun thinking of ways to get around the trademark problem: putting smiley faces over Orville and Wilbur, or placing a black bar over their eyes. But they decided to take the safe route and revamped the aviators to look like 1930s barnstormers. "They're Frank and Joe Wright, the other two brothers you don't hear much about," Lawrentz says.

The Richman agency represents 48 famous clients—most deceased—including Albert Einstein, Sigmund Freud, Mae West, Rudolph Valentino, Al Jolson, Carmen Miranda, and Chico and Harpo Marx. Under a combination of state common law, right-of-publicity statutes, and U.S. trademark law, use of their names and likenesses can be limited to those given permission by the client or those willing to pay license and royalty fees. License fees or royalties are typically 10 percent of wholesale value and up to a five percent advance. The Beverly Hills company gives 65 percent of the proceeds to the Wright Family Fund and keeps 35 percent.

Stephen Wright, 44, says that his late father, Wilkinson Wright, the brothers' grandnephew, received the approval of all the heirs to Orville Wright's estate to establish the fund in 1995. Since then, he says, over $443,000 has been donated to 12 aviation-related organizations in Ohio, North Carolina, and Virginia.

Wright and his sister Amanda are the trustees of the fund. "My father's intention was to benefit charitable causes, which is what this has done," Wright says. "Our family—it's been unwritten law that we don't profit from the name of the Wright brothers or their accomplishments. But we're not averse to using their names to advance a charitable cause."

Representatives of the Smithsonian Institution, which displays the 1903 Wright *Flyer* at the National Air and Space Museum, are examining the legal issues involved, says institution counsel Lauryn Grant. "To the extent that these

trademarks would interfere with us carrying out our mission, we would object to that," she says.

Applications for U.S. trademarks have been filed for "the Wright Brothers," "Orville & Wilbur," the words "100 years of aviation celebration"—even the famous photo taken as Orville and the *Flyer* lift off while Wilbur runs alongside. The agency has recently begun a marketing campaign to license products and sign endorsements for advertisements. Editorial, educational, and some creative uses would be exempt from trademark protection.

Facing the prospect of unanticipated costs or prolonged legal battles, many Outer Bankers are back-pedaling on plans for merchandising and advertising campaigns leading up to the centennial celebration in December 2003.

"I just worry about the effect it could have on 2003, because a lot of merchandise has already been printed," says Outer Banks Chamber of Commerce spokeswoman Angie Brady-Daniels. "Since 'Wright Brothers' is one of the things they've trademarked, there's a lot of concern. What are we supposed to do, say 'the Brothers?' "

—Catherine Kozak

HEADS UP

EAA

EAA's Spirit of St. Louis Tour

The Experimental Aircraft Association's replica of the *Spirit of St. Louis*, participating in the Lindbergh Foundation's commemoration of the 75th anniversary of Charles Lindbergh's solo transatlantic flight, will visit several cities after landing in St. Louis and New York in May.

- West Bend, WI, June 14–16
- St. Louis, MO airshow, July 4–7
- EAA Airventure, Oshkosh, WI, July 23–29
- Little Falls, MN (Lindbergh's boyhood home), Aug. 9–11
- Kansas City, MO Aviation Expo, Aug. 17

This is the EAA's second *Spirit* replica. The first, built in 1977 to celebrate the flight's 50th anniversary, re-created Lindbergh's post-flight U.S. tour. After logging more than 1,300 hours of flight time in demonstrations, the airplane retired to the EAA Airventure Museum in Oshkosh, Wisconsin, in 1988. So many people requested appearances that the association completed a second replica in 1991.

New Zealand Air Deco

In any other context, it might seem a trifle odd that the dapper man admiring a D.H.82A Tiger Moth looks like he's on his way to a Gatsby-era picnic. But at Napier, which hosts one of New Zealand's annual airshows, that dress style is an unwritten rule. Each February, Napier holds an Art Deco Weekend to pay homage to its architectural heritage—the seaside town of 55,000 was destroyed by a 1931 earthquake and rebuilt almost entirely in the Art Deco style. For the past five years, the Napier-based Vintage Aviation Charitable Trust has staged a companion three-day airshow, dubbed Aero Deco, at the town's small airport.

The organizers try to stay true to the festival's theme by showcasing airplanes built in the 1920s and 1930s, but they've bent the rules to allow some mid-century aircraft onto the bill. A couple hundred visitors stroll along the grassy field admiring more than a dozen biplanes and monoplanes flown in from all over New Zealand. (Another dozen aircraft couldn't make it this year because of bad weather over the nearby mountains.)

When the clouds lift, the spectators take in the aerobatic team known as the "Roaring Forties" (named for the T-6 Harvard's vintage, as well as New Zealand's latitude). The more adventurous visitors take rides in the DC-3, D.H.104 Devon, D.H.83 Fox Moth, or the Catalina amphibian, swooping over the vintage cars and picnickers gathered along the Marine Parade.

Aero Deco attracts an unusual mix of aviation aficionados, Art Deco fans, and people looking to enjoy a good spectacle, many of them sporting vintage outfits. Undeterred by the occasional drizzle, Michael "Biggles" Murrie-Jones, a health department purchasing officer from Brisbane, Australia, showed up for his second festival visit. Murrie-Jones was decked out in a World War II-era Royal Australian Air Force uniform, capped with a vintage helmet, goggles, and life preserver scrounged from flea markets. It was his way of honoring his great-uncle, killed in the Battle of Britain. But also: "It's just fun," he confessed, excusing himself with a cheery "Chocks away!"

—Luba Vangelova

LUBA VANGELOVA

Natty New Zealanders lined up for rides in the Catalina at Aero Deco.

SOUNDINGS

Aiming for the Ignorusphere

This summer will see the first attempt to break the world altitude record for a manned balloon flight in nearly 40 years, ever since Malcolm Ross and Vic Parther of the U.S. Navy reached a height of 113,740 feet on May 4, 1961, the same year in which Yuri Gagarin blasted into space in Vostok 1. Gagarin's orbit of Earth started a new phase in the space race that since 1927 had consisted of sending people to the edge of space in balloons.

International space programs since then have concentrated, not surprisingly, on exploring space, leaving the upper atmosphere unexplored for decades. "Lots of scientists call [the upper atmosphere] the Ignorusphere because it's an area that's completely ignored," says Andy Elson. He and fellow British balloonist Colin Prescot, sponsored by QinetiQ, Europe's largest science and technology organization, are aiming to change that. Launching from a vessel off the coast of southwest England, they hope to fly their *QinetiQ 1* balloon to an altitude of 132,000 feet.

QINETIQ

The helium-filled balloon, when inflated, will be as tall as the Empire State Building, and will be the largest manned balloon in history: 40 million cubic feet in volume—four times the size of Ross and Parther's balloon.

QinetiQ 1 will also carry a number of experiments, notably QinetiQ's Cosmic Radiation Effects and Activation Monitor study. Cosmic radiation particularly affects people who spend long periods at altitude, such as airline pilots.

CREAM has already traveled on the space shuttle, Mir, and the Concorde, but *QinetiQ 1* will take CREAM to the gap between the Concorde's cruise altitude of 11 miles and the lower shuttle altitudes of 150 miles.

High winds during the two-hour inflation process could tear the balloon to shreds—more importantly, the same thing could happen above 80,000 feet if there are significant winds in opposing directions. The team's launch window runs from July 1 to August 20, when the weather is most predictable.

Strapped to an open platform, the pilots will be exposed for 12 hours to elements that will include temperatures ranging from 59 to –158 degrees Fahrenheit and ambient air pressure low enough to make blood boil in an instant. To protect against these conditions, Elson and Prescot will wear two thermal layers underneath pressurized spacesuits, which will themselves be insulated by thick down cocoons.

Prescot and Elson, both experienced pilots (the latter was the first to fly a balloon over Mount Everest), are unfazed. "To go to this kind of altitude and to attempt to do something that has not been done for over 40 years is the ultimate professional challenge for balloonists," says Prescot. "I've always had my eye on it."

—*Douglas Andrews*

UPDATE

No-Shows

The following airshows ("Airshows Coming Soon to a Field Near You!" Apr./May 2002) have been canceled due to increased activity at the bases since September 11.

Travis Air Force Base Airshow, CA, June 15 and 16

Scott Air Force Base Airshow, Belleville, IL, June 21–23

Charleston Air Expo, Charleston Air Force Base, SC, June 23

McChord Air Force Base Open House, WA, Aug. 24 and 25

Requiem for the Hudson Corridor

New York City's Hudson Corridor was one of the most majestic journeys that private pilots could make. In the early 1970s, the Federal Aviation Administration established the New York Terminal Control Area, which set aside a chunk of airspace for light aircraft that enabled them to sneak under the traffic of LaGuardia, Kennedy, and Newark airports for a little sightseeing. From the north, you'd cross the George Washington Bridge at 1,000 feet, then cruise down the right side of the Hudson, slowly descending to 500 feet and lower. Yankee Stadium glided by on your left, then Central Park, followed by the aircraft-carrier-turned-museum USS *Intrepid* (on which you thought you could land if engine trouble developed). You'd look up at the Empire State Building and the twin towers of the World Trade Center from an altitude of roughly half their height. Over New York Harbor, you'd circle the Statue of Liberty at 300 feet. With the Verrazano Narrows Bridge in the distance, you'd warn your passengers of a tight turn to come, look around for traffic, drop the left wing, and pull back on the stick to their delighted squeals. You'd point out the ships and ferries plying the harbor, fly over Governors Island, then head back up the Hudson and see it all again.

FAA

"It's one of the most romantic flights that you can make," says New Jersey pilot Joe Castanza. "One of the things I always enjoyed the most was taking someone who had been flying only a few times and watch them light up. It did something to people. Flying down it, especially at night, you can see the flickering of car lights on all the avenues and streets. There wasn't a single weather situation when it didn't look pretty."

Then came September 11, and the FAA closed the corridor to "uncontrolled" flights. In other words, the pilot would have to be in contact with air traffic controllers, something ATC didn't encourage and private pilots aren't used to.

On December 19 it opened again—partially. According to Arlene Salac, public affairs officer for the FAA's Eastern Region, pilots can fly from the south up to the Statue of Liberty and back, or down from the north to turn around at the Empire State Building. They simply can't fly within a two-mile radius of "ground zero," where the World Trade Center once stood. Whether the Hudson Corridor will ever reopen fully is unknown. "We have no indication when [the restriction] will be lifted," says Salac.

—*Phil Scott*

WORK IN PROGRESS

MIKE GALLAGHER/AAFO.COM

Rare Bear Wants Back in the Air

The world's fastest piston engine racer has been grounded since 1999. Lyle Shelton's highly modified Grumman F8F Bearcat set a world closed course speed record of 528 mph in 1989 and won the Reno Air Races from 1988 through 1991 (setting a Reno speed record of 481 mph in the process). Mechanical and financial problems kept the airplane out of the spotlight for the past few years, but Shelton is determined to get *Rare Bear* back in the air for this year's Reno races, held in September. "Our objective is to get a good racing engine with a spare, do 15 to 20 mph of drag reduction mods on the airframe, and run into the indefinite future as the world's fastest race plane," Shelton says. That will require a minimum of $250,000. "Surplus military R-3350-26W engines from AD Skyraiders are costing $25,000 to $50,000 now, not overhauled. A few years ago they were about $5,000. Many modified Sea Furies are using them now, driving costs up."

Join the *Rare Bear* Fan Sponsor Club at www.rarebear.com; write to Rare Bear Air Racing Team, 245 Liberty St., Suite 240, Reno, NV 89501; or call (208) 642-2071.

NASA's Nuclear Revival

After three decades of lip service, NASA has come up with a $1 billion five-year plan to revive research and development of nuclear power systems for robotic space probes.

"It's been a long time since you could say the word 'nuclear' in Washington," says NASA's space sciences chief Ed Weiler. "But if we're serious about space exploration, this is the right thing to do."

The request is part of President Bush's 2003 budget, which is pending Congressional approval. The Nuclear Systems Initiative, which would receive an initial $125.5 million, includes funding for research on nuclear propulsion systems and the purchase of plutonium electrical generators to power spacecraft for long missions. NASA wants to make the switch to nuclear power for a sophisticated Mars rover that had been scheduled for launch in 2007 but is being delayed two years for design modifications.

Engineers are preparing to replace the rover's solar panels with an electrical system powered by the breakdown of radioactive plutonium. These systems, which are called radioisotope thermoelectric generators, or RTGs, have been used in dozens of spacecraft, including the Mars Viking landers, the Voyager interplanetary travelers, the Jupiter probe Galileo, and Saturn-bound Cassini.

"You know what our current inventory of RTGs is now?" says Weiler. "One. That's it. There's one RTG on the shelves."

The solar-powered Sojourner rover, which was part of NASA's 1997 Mars Pathfinder mission, lasted about six weeks. If it had been outfitted with an RTG, the mission likely would have lasted at least a couple of years, says NASA's Mars exploration program head, Jim Garvin.

NASA buys RTGs from the U.S. Department of Energy, which plans to restart its plutonium production lines. In the interim, the Department of Energy intends to buy its radioactive wares from Russian suppliers, says Earl Wahlquist, associate director for the agency's Space and Defense Power Systems.

Equipping spacecraft with nuclear-powered propulsion systems, however, remains decades away, and the agency has no plans whatsoever to develop nuclear rockets to hoist probes off the planet's surface. Rather, the reactors, which, like nuclear power plants on Earth, would use enriched uranium, would not be powered up until they were in orbit.

The Nuclear Systems Initiative already has drawn fire. In addition to questioning the safety of launching nuclear systems into space, anti-nuclear activists say NASA is fronting for the military, which wants nuclear reactors to power proposed space-based laser defense systems. "The distinction between civilian and military is being rubbed out," says Bruce Gagnon, coordinator of the Florida-based Global Network Against Weapons and Nuclear Power in Space.

NASA officials say that space nuclear systems are needed because of the laws of physics, not politics. "The sun ceases to be much of a useful power source beyond Jupiter," says Weiler. "That's not really the way to explore the solar system."

—*Irene Brown*

A French Treasure

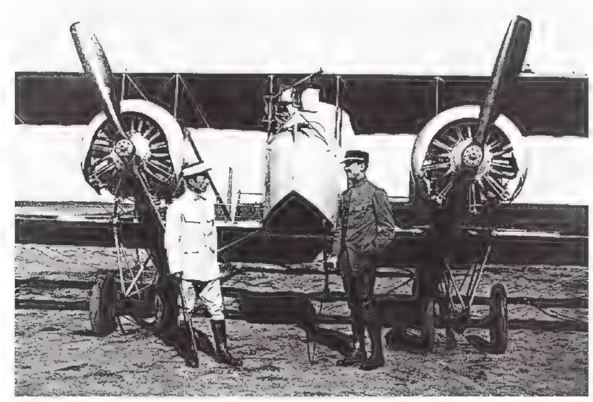
Squeeze past the mighty Boeing B-29 *Enola Gay* and the banana-yellow Northrop Flying Wing and you'll find the Caudron G.4, a French biplane bomber built in 1916. The Caudron is skewered on a cantilevered rack and braced against the corrugated walls of Building 20 at the Paul E. Garber Preservation, Restoration and Storage Facility in Suitland, Maryland. The Caudron and the dozens of other artifacts wedged inside are awaiting a 45-mile ride to Dulles International Airport in northern Virginia, where they'll take up residence at the National Air and Space Museum's Steven F. Udvar-Hazy Center next year.

For the past two years, Garber restoration specialists Ed Mautner, Scott Wood, and Caudron team leader Karl Heinzel have meticulously conserved and repaired the French bomber. Now, as preparation for the Caudron's eventual transport to Dulles, they've stripped its 7.7-mm machine gun, tail booms, dual propellers, and wingtips to streamline the load. And Heinzel is thinking outside the box. With a wingspan of just over 56 feet, "the Caudron airframe is eight inches too wide for a box trailer," he says. "But with a fabric-sided trailer, we can kind of stretch the truth."

On December 27, 1916, the two-week-old Caudron G.4, no. C4263, made its first flight, at Issy-les-Moulineaux, near Paris. The pilot climbed to 3,280 feet in seven minutes. Shortly after, C4263 was sent to the Réserve Générale of the Aviation Militaire Française. "As near as we can figure, it has no operational experience," says Heinzel. "They would have used castor oil to lubricate the rotary engine, and there's not a single streak."

The Museum's Caudron is a rare prize, among the oldest surviving bombers and the only very early multi-engine airplane in the Smithsonian collection. Only one other Caudron survives, a fully restored example at France's Musée de l'Air. The Caudron G.4 was one of the first Allied aircraft armed with a machine gun. By war's end, the Caudron, which had a top speed of 82 mph, was manufactured not only in France but also in England and Italy and was used by all Allied powers, from Belgium to China and Russia. Britain's Royal Flying Corps used Caudrons to bomb German seaplane and Zeppelin bases.

French brothers Gaston and René Caudron built the machine to pre-war norms. Lateral control was achieved through wing warping. A Caudron G.4 weighed only 1,616 pounds empty, was mechanically reliable, and was pleasant to fly, making it ideal for reconnaissance and flight training. The bomber version



NASM NEG 2002-2589

The Caudron G.4 served as a bomber and recon craft. The Museum's Caudron (below) is one of only two in the world.

ERIC LONG

COMING IN 2003

The National Air and Space Museum is building the Steven F. Udvar-Hazy Center, a facility to display and restore part of its collection of historic aviation and space artifacts. Located at Washington Dulles International Airport in northern Virginia, the Center will open late next year. In addition to restaurants, a movie theater, and an observation deck, the Center features a 104-foot-high hangar (below), in which 73 aircraft will be suspended from the ceiling (each arch can hold up to 20,000 pounds). For more construction site photographs, visit www.nasm.edu.


MARK AVINO

could carry 249 pounds of ordnance, and the trainer offered dual controls. Including all three variants, a total of 1,358 Caudrons were manufactured.

Early in 1917, Caudron no. C4263 was purchased by the U.S. government, and photographs show it at Langley Field in Hampton, Virginia, by July 26, 1917. Four months later, the U.S. ordered 10 more. "There was nothing particularly special about the Caudron," says Museum aeronautics curator Peter Jakab. "When we entered the war in 1917 there wasn't time to work on original designs. The thinking was to test established European designs and build one." By the time the Caudron was shipped to the United States and reassembled, it was obsolete. On July 12, 1918, the War Department offered the Caudron to the Smithsonian, and it was delivered to the Arts and Industries Museum two months later.

Heinzel fingers a 1916 drip of paint on the wing fabric. "The public thinks of restoration as shiny new and glossy, but a vintage aircraft in real wartime condition looks terrible," he says. Like most battlefield deliveries, the Caudron was hastily assembled in the field, then painted with a rough brush. "We restore them to historic accuracy," says Heinzel. "Museum visitors think we were just sloppy."

The first task was replacing the makeshift display engine. One 80-horsepower Le Rhône, original to the period, was found and installed. The second rotary engine was missing its nine copper intake pipes, so Heinzel and Jakab went prospecting. "When these engines were junk surplus in the 1930s, people scavenged them for the copper pipes," says Jakab. Now, he notes, "other museums need intake valves, so they are very desirable in the antique restoration market." The price in barter was too high. "Some individuals wanted us to trade whole engines for copper pipes," he says.

Heinzel leans in. "I'm full of secret tidbits," he whispers. "There is a cutaway engine at NASM of the FE-8, in the World War I exhibit. We took off those copper intakes, cast them in resin, and reinstalled the casts [on the FE-8]. We did such an accurate reproduction you can't tell." Heinzel's team placed the real deals into the Caudron.

A propeller original to the period was found and installed, and Heinzel's team precisely copied its pattern in walnut wood for the other engine. Propeller decals will be duplicated to match those of the original French manufacturer, Gremont.

For now the props, original and copy, are in storage at Garber. Future generations will not be able to easily distinguish the original from recent craftsmanship. Except perhaps, for the stencil on the new propeller's center, which will be hidden when mounted. "NASM 2001 KLH" it reads. Karl L. Heinzel grins and glances at his feet.

—Roger A. Mola

MUSEUM CALENDAR

June 1 Evening Stargazing. Join Sean O'Brien, staff astronomer of the National Air and Space Museum's Einstein Planetarium, for an evening that will begin with a short night sky orientation, followed by guided viewing of various astronomical objects through a telescope. There is a $2 park entrance fee per vehicle. Please cover flashlights with a red filter or a brown paper bag. Dusk to 11 p.m. at Sky Meadows State Park in Paris, Virginia. For directions, call (540) 592-3556.

June 6 Jaylee and Gilbert Mead Exploring Space Lecture: "Three-Dimensional Mapping of the Dark Universe?" J. Anthony Tyson, a distinguished member of the technical staff at Lucent Technologies/Bell Labs who specializes in experimental gravitation and cosmology, will describe contemporary efforts to map the dark matter structure of the universe, using instruments like the proposed Dark Matter Telescope. Tickets are required and may be obtained through Tickets.com by calling (800) 529-2440 or visiting www.tickets.com. Admission is free but there is a small service charge for each ticket. Langley IMAX Theater, 8 p.m.

Summer Hours The National Air and Space Museum is open from 9 a.m. to 5:30 p.m. from May 24 through September 2. General admission is free.

Lockheed Martin IMAX Theater Experience the thrill of films produced in IMAX and projected onto a screen seven stories wide and five stories high. Feature films include *To Fly!* and *Space Station 3D*. For more information, call (202) 357-1886 or (202) 357-2700.

Albert Einstein Planetarium Embark on a celestial adventure. Realistic astronomical experiences are produced under the planetarium's 70-foot dome. For information, call (202) 357-1686.

Except where noted, no tickets or reservations are required. To find out more, visit www.nasm.edu *or call the Smithsonian Information line at (202) 357-2700; TTY (202) 357-1729.*

No Way Out

Space shuttle *Columbia*, Thanksgiving day, 1996. Astronaut Tammy Jernigan grasped the airlock depressurization valve. She rotated the black knob to the open position; air began whistling from the chamber directly into space. Hovering above her spacesuit's backpack, I glanced down at the digital readout on my own suit and watched the pressure in *Columbia*'s cramped airlock creep toward zero.

The countdown to our first extra-vehicular activity, or spacewalk—a high-profile test of space station construction techniques—had gone perfectly thus far. We'd spent the morning hustling through the preparation checklist with veteran spacewalker Story Musgrave, our choreographer and taskmaster. He'd guided us through every detail of suit-up, checking and double-checking; about 30 minutes ago, he'd closed the hatch into *Columbia*'s middeck behind us. Tammy and I were on our own.

Racing through our minds were the details of the six hours of work that lay ahead. At the old WETF—Weightless Environment Training Facility—at NASA's Johnson Space Center in Houston, Tammy and I had put in more than 130 hours underwater in our bulky suits, rehearsing within the submerged mockup of the shuttle payload bay. In each grueling session, we'd run through a tightly scripted series of tests: putting a new space station cargo crane through its paces, demonstrating the replacement of a dishwasher-size solar array battery, and working the kinks out of nearly a dozen new tools. The WETF runs seemed endless, and we could hardly believe it when we wrapped up the last rehearsal and climbed from our dripping suits for the last time. Now we were wearing the real thing, about to go to work in earnest.

When the airlock pressure reached five pounds per square inch, Tammy halted the depressurization for a spacesuit leak check. Her suit pressure was a trifle high, but her breathing would soon remove enough oxygen to bring the reading within limits. My pressure gauge was right on the money at 4.3 pounds per square inch—in a pure oxygen atmosphere, that's all the pressure needed to fully charge our blood with oxygen. Tammy twisted the depress valve wide open, and the remaining air molecules fled into the void outside.

Still connected to the orbiter by our suit umbilicals, we got the "Go" from Story to open the airlock hatch. The butterflies in my stomach were all in full zero-G flight; I was more fearful of making a mistake outside, in front of my colleagues, than of micro-meteoroids, searing temperatures, and hard vacuum. In a moment we'd be out the door and really "on stage." With one hand on the yellow handrail rimming the outer hatch, Tammy grabbed the hatch handle and cranked it clockwise.


NASA

Further into the shuttle flight, Thomas Jones and Tammy Jernigan could almost laugh about their predicament.

The handle jerked to a stop after about 30 degrees of travel. As she put more muscle into the move, her body swung toward me, the force reacting back through her arm and torso. At first I thought it was just a sticky spot in the handle travel, but after half a dozen straining attempts—I could hear her breathing with effort over the intercom—she couldn't get the handle to move any farther. "Tom, it won't budge," she said. "Swap places with me. You have a go at it."

I squeezed by Tammy, floated some bobbing tools out of the way, and grabbed the handrail for leverage. Then I shoved the forged-steel handle clockwise. *Thunk.* It smacked solidly into some obstacle at the 30-degree mark. After several grunting attempts to force the handle around, I could see we had a struggle on our hands. We were nowhere near turning the handle the one full circle required to retract the metal rollers that held the hatch against its seals. There was nothing obvious in the way, yet the handle felt like it was jamming against a hard metal stop. Unlike a sticky gasket or some frozen lubricant in the gears, this kind of hardware problem was new to both of us.

Pivoting to face Tammy, I caught her glance behind her helmet faceplate. She shook her head in amazement, and both of us mouthed silent oaths of disgust. In words pitched with disbelief, she described our predicament to Story and asked for help. We were in a surreal situation: Just an eighth of an inch of aluminum separated us from the experience of a lifetime.

The word went down to Mission Control. We could just imagine the stunned reaction there. Our flight director would be glaring at our instructor, Glenda Laws: "You're telling me they can't get the door open?!" As we discussed the problem with Houston, Tammy and I each tried again to exert maximum leverage on the stubborn handle. Nothing. The EVA team on the ground had us try everything they could think of—even the obvious. I could hear the apologetic tone accompanying capsule communicator Bill McArthur's mandatory question: "Tom, uh, please confirm you're turning the handle in the clockwise direction?" I'm sure he winced at the impatience in my voice as I snapped, "Affirmative!"

The two of us scrambled for a position

that would help us deliver more torque to the handle. Trying for more leverage, I got a boot on the end of the handle and strained against it, bracing my gloved hands against the ceiling, but Houston quickly called me off that technique, fearing that that much force could damage the gears and linkages in the hatch mechanism. Next mission control had us disconnect the handle from the gear housing and inspect it for debris or damage—nothing out of order. Tammy and I were in no danger—we were using *Columbia*'s oxygen and electricity, and we had hours of carbon dioxide scrubber capacity left—but we refused to admit there was a possibility we would not get the hatch open. No shuttle hatch had ever malfunctioned. Though we'd trained underwater to free a jammed hatch linkage from the outside, we never dreamed we'd be unable to get it open from the inside. Everything we could see from within our closet-size airlock was maddeningly in order, and our crew's video survey of the hatch exterior showed nothing amiss.

We were in a surreal situation: Just an eighth of an inch of aluminum separated us from the experience of a lifetime.

After two hours of futile attempts, and with no obvious avenues of attack to pursue, mission control advised us to hang up our spacesuits for the day.

Thanksgiving dinner aboard *Columbia* that night was a gloomy affair, all of us struggling to find reasons for optimism while skirting our frustration. Like me, Tammy was deeply disappointed over our mission's first significant setback. As EVA lead, she felt keenly not only her own lost opportunity but also the impact on our colleagues, who'd worked for months to train us and build the test hardware. The holiday menu of rehydrated shrimp cocktails, Dinty Moore turkey dinners, and warm tortillas couldn't disguise the bad taste of failure.

Next morning, we expected to wake to news that Houston had found the key to the problem and that we'd be headed outside later in the day. Instead, we spent the day taking measurements around the hatch's interior surface, looking for a misalignment. Tammy and I fitted makeshift tethers to a crowbar and mallet from *Columbia*'s toolbox, confident we could "nudge" open the hatch on our second attempt. But Houston's wake-up music on November 30, the Doors' "Break on Through to the Other Side," couldn't soothe the sting of learning that our mission's two EVAs had been scrubbed.

NASA managers made the right call. If we'd forced open the hatch and then couldn't reseal it on the way back in, we'd be marooned on the wrong side of a pressure bulkhead. To save us, our crewmates would have to execute an emergency reentry with us in the airlock, leaving the multi-million-dollar ORFEUS/SPAS ultraviolet spectrometer telescope we'd deployed on launch day stranded in space.

As our 18-day mission wound down, our spirits slowly rebounded. Our two science satellites had performed superbly, and I was in orbit, weightless, blessed with good companions and incomparable views of Earth and space. Thanksgiving had indeed come to *Columbia*'s crew—just a few days late.

Strapped in for reentry, the one fear Tammy and I still harbored was the embarrassing possibility that once back on Earth, the hatch would open—normally. Just the thought of it made me shiver, despite the furnace-like plasma surrounding *Columbia* as we plunged back to Earth. It wasn't until a couple of days after touchdown that we got the welcome word from the Cape—the hatch was still jammed. X-rays showed a small screw missing from the handle's sealed gear train. When engineers tore down the mechanism, they finally solved the mystery: The loose screw had floated into the gear teeth and remained trapped there in sticky lubricant. The half-inch-long screw had jammed the gears like a chock thrown under an aircraft tire.

NASA quickly imposed new inspections and tests to prevent future hatch problems. And to our great relief, chief astronaut Bob Cabana promised he'd do his best to get us another shot at an EVA. Tammy Jernigan broke on through in 1999, with nearly eight hours of construction work outside the International Space Station. As for me, a little over four years after the turn of our screw, I opened *Atlantis*' hatch on STS-98 and floated gingerly out into the brilliant sunlight in the shuttle's payload bay. It was a grand entrance, one to be savored for a lifetime. Fittingly, on my office wall today hangs a photo of Tammy and me in our suits—mounted next to my half of the offending screw.

—Thomas D. Jones

Son of Rocket Belt


Kinnie Gibson rocketed to about 70 feet at the 1985 Superbowl at Palo Alto, California.

POWERHOUSE PPRODUCTIONS INC. (3)

By the age of 11, I was a rabid James Bond fan. I chose "Sean" as my Catholic confirmation name, a blatant act of hero worship honoring the original Bond, actor Sean Connery. Thus, when the suave British agent (actually, his stunt double) took off in a Bell Rocket Belt in the opening sequence of the 1965 film *Thunderball*, I was hooked. The Jetsons-style flying machine was way cooler than the Taylorcrafts or Ercoupes I flew back then with my father. I assumed that Rocket Belts would one day become as common as Volkswagen Beetles.

Thirty-six years later, the Bug basks in newfound acclaim while the Rocket Belt remains a minor footnote to aviation history. Built by Bell Aerospace of Buffalo, New York, only a scant few of the prototypes survive.

However, various derivatives of the originals were built, and so the hydrogen-peroxide-powered flying contraption has not been completely relegated to museum status. Dallas-area entrepreneur Kinnie Gibson owns three, and actually makes a business of flying them.

Most sane pilots would launch in the notoriously unstable Rocket Belt only at gunpoint, while totally inebriated, or both. But Gibson relished the idea. A self-described practitioner of what he calls the "dangerous" sports, he raced motorcycles as a kid, took up skydiving at 18, and later joined a skydiving demonstration team. In 1976 he started a hot-air balloon company. He toured with Evel Knievel in Australia, where he piloted balloons as part of the "Evel Knievel Thrill Spectacular." This led to stunt work in Hollywood. He appeared in numerous films and recently completed his 11th season as stunt double for Chuck Norris in the "Walker, Texas Ranger " TV series.

In 1981, while working for a California hot-air balloon operator, he discovered a Rocket Belt in a company warehouse. The unit was a close copy of the original Bell design. It had been fabricated by one of the owners of the balloon company, who had flown it himself on occasion. Gibson asked to try it, and eventually got his chance. After listening to a short lecture on basic operating theory from the owner, he made the first of 31 flights tethered to a cable. Satisfied that he understood the beast sufficiently, he made his first free flight. Soon thereafter he bought the unit and began flying it at public venues, like mall openings and car shows.

The Rocket Belt runs on a 90 percent hydrogen peroxide solution contained in two small tanks worn on the pilot's back. A larger central tank contains pressurized nitrogen, used to force the hydrogen peroxide over a silver-lined catalyst bed that decomposes the solution. The non-combusting byproduct is a super-heated steam exhaust. The process is simple and reliable, says Gibson, and once the catalytic reaction is started, it is unlikely to be interrupted. The steam is vented through two tubes positioned eight inches behind the pilot's body and angled slightly away, producing as much as 300 pounds of thrust. The tubes are mounted on gimbals, which allow the pilot to direct the exhaust for maneuvering. The pilot can vary the strength of the thrust by manipulating a motorcycle-like hand grip that controls a throttle valve.

After numerous tear-downs of his first Rocket Belt for maintenance, Gibson decided he could improve on the design. Using lighter and stronger materials, he crafted two new belts, increasing flight endurance by nearly a third. The engine would now run for all of 30 seconds, rather than just 21.

Gibson, who has flown the 130-decibel banshees at racing rallies and amusement parks, while touring with rock bands, and at Hollywood opening night bashes, says the Rocket Belts are extremely tricky and easy to over-control. Placing one's legs in the 1,200-degree-Fahrenheit exhaust streams is not recommended. A stopwatch marked with yellow (for caution) and green ranges serves as fuel gauge. Touching down with three to four seconds of propellant remaining is the goal, but a few times the stopwatch (and fuel) has run out before Gibson had quite rejoined terra firma.

With every flight starting as a fuel emergency and going downhill from there, mishaps are perhaps predictable. After several of what Gibson calls "minor" crashes and one accident that nearly resulted in the amputation of a foot, he has slowed down a bit. Nowadays much of the flying is done by Eric Scott, an employee of Gibson's company, Powerhouse Productions.

In its first incarnations, the Rocket Belt's minuscule range and other logistical issues proved insurmountable obstacles to wider acceptance. Nevertheless, the Belt remains an intriguing and still somehow futuristic flying machine.

—*Vincent Czaplyski*

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The Birth of Spooky

HOW THEY PUT THE "A" IN THE AC-47.

BY MARSHALL MICHEL

With the side-firing AC-47, the Air Force finally had a way to track and attack elusive guerrilla fighters, even in the thick jungles of Vietnam.

U.S. AIR FORCE MUSEUM

"Afghan resistance forces, in conjunction with American Special Forces and supported by AC-130 gunships, have begun their push today toward…" This quotation could have come from any of a hundred news stories on the war that broke out after September 11. Occasionally one of the 24/7 news networks airs a film clip showing a large four-engine aircraft identified as an AC-130 in a left turn, long streams of flame coming out of guns extending from its side, looking for all the world like a sailing ship from the early 19th century firing broadside.

To most of the world, gunships, along with Airborne Warning and Control Systems (AWACS), precision-guided munitions, and aircraft carriers, have become the ubiquitous symbol of U.S. post-Vietnam military power. Only the gunship, however, is a uniquely American weapon, conceived by a handful of determined individuals in response to a specific combat problem. It evolved despite huge bureaucratic obstacles and intraservice fighting.

The first aircraft to test the side-firing concept, a Convair C-131, was rigged with a single 7.62-mm mini-gun pod mounted on a cargo pallet and positioned at the rear cargo door.

Side-firing gunships are "one of the most successful developments arising from our experience in Southeast Asia," General John Ryan, then Air Force chief of staff, concluded at the end of the Vietnam War. Colonel Ron Terry, a former fighter pilot who led the charge in the early 1960s to develop the AC-47 and its successors, the AC-130 and AC-119, points out today that the gunships have been one of the most "effective things the United States has had for engagements in Panama, Grenada, and Afghanistan."

The idea of a side-firing aircraft has a long history. The U.S. Army Air Corps mounted a .30-caliber machine gun on a DH-4 mailplane in the 1920s and the French mounted a side-firing 75-mm artillery piece on a bomber, but the side-firing weapon did not seem to offer any advantages over conventional mounts—it was an answer without a question. As Terry puts it, most combat planners felt that "military aircraft should dive at the ground, drop bombs, shoot guns. They don't fly in circles."

The first person to come up with the problem the side-firing gun might solve was Lieutenant Gilmour McDonald of the U.S. Coastal Artillery, who suggested one for anti-submarine warfare in 1942. Such an aircraft could orbit a surfaced submarine—a maneuver known as a pylon turn—as the gun kept up a stream of fire at the submarine, eliminating the need to dive, attack, pull off, then reacquire the target to repeat the attack. The military did not adopt the idea, and McDonald's work languished for almost 20 years, until the early rumblings of the Vietnam War.

In his book, *Deployment and Employment of Fixed Wing Gunships*, Jack Ballard tells it this way: In 1963, Ralph Flexman, a friend of McDonald's and an engineer at Bell Aerosystems, applied the side-firing gun idea to the new problem of transient targets in a guerrilla war. He realized that by firing in a continuous turn the aircraft could keep the targets in sight constantly. Flexman shared his insights with Captain John C. Simons, an Air Force friend stationed at Wright-Patterson Air Force Base in Ohio, who in turn proposed the idea later that year to several groups interested in counter-insurgency warfare.

Analysts in the Air Force's Aeronautical Systems Division rejected the proposal as unsound because they thought that the bullet drop would make firing from such a flight path highly inaccurate. But Simons refused to give up. He experimented with pylon turns in a single-engine T-28 trainer and found it was easy to keep a target in sight during the maneuver. He got the military interested enough to assign it a name—project Tailchaser—and to give him access to a twin-engine C-131 trainer, the military version of a Convair 240 airliner.

AC-47s could fire accurately from as high as 3,000 feet.

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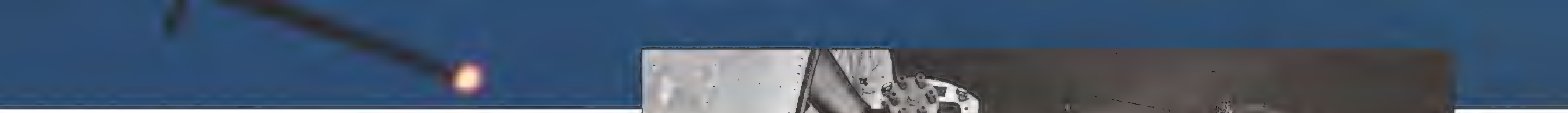


USAF

In just one minute, the AC-47's mini-guns could fire 6,000 rounds each, gobbling up the aircraft's ammunition.

Simons put a fixed sight and three cameras on the C-131 to record target tracking, but during the next year only a handful of flights could be made, due to a lack of funds. The program was for all practical purposes moribund when Captain Ron Terry arrived at the Flight Test Division at Wright-Patterson in 1964.

Cometh the hour, cometh the man. Terry, who had flown F-86s and F-100s, had just returned from looking at all aspects of air operations in Vietnam as part of an Air Force Systems Command team. While there he had learned that the Viet Cong had begun regularly attacking U.S. Special Forces outposts and Vietnamese hamlets at night to avoid air counter-attacks and that Air Force fighters had virtually no night attack capability. On the positive side, he noted that the U.S. flare ships—C-123s and C-47s—orbiting over hamlets at night effectively illuminated surrounding areas to protect against night attacks.

When Terry arrived at Wright-Patterson he went through old project reports and found Tailchaser. Intrigued, he flew with Simons on the modified C-131 and found that they could track a fixed point on the ground with ease if they held a steady banked turn. Terry realized that in defense of hamlets and forts, an aircraft with side-firing guns was the next logical step beyond flare ships. "Tailchaser was a real major breakthrough," he says. "It gave the pilot a much longer tracking time."

A SIDE-FIRING AIRCRAFT COULD ORBIT a surfaced submarine—a maneuver known as a pylon turn—as the gun kept up a stream of fire, eliminating the need to dive, attack, pull off, then reacquire the target to repeat the attack.

Terry got approval for a live-fire test at Eglin Air Force Base in Florida. Since the program wasn't officially funded, he had to use his personal American Express card to purchase tools and hardware. Then he flew down in the C-131 with a small team.

At Eglin Terry recruited Lieutenant Ralph Kimberlin, the project officer for a new Gatling-type 7.62-mm mini-gun, the SUU-11A, which fired 6,000 rounds a minute. The two men mounted the gun on the C-131, aimed it out the cargo door, wired the trigger to the pilot's wheel, then had Ken Cobb, another engineer at Eglin, work out ballistic trajectories and firing tables for the system so the guns could be fired accurately. Cobb remembers Terry as "a very strong and determined leader, free spirited and sort of an adventurer."

The modification and calculations complete, Terry and his team headed for a raft target in the Gulf of Mexico. Terry orbited the target and began to blaze away, and Kimberlin remembers that "he frothed up the water all over the target while the cameraman took pictures, and we realized that the airplane could sit at 3,000 feet and shoot down at troops out of small arms range. We began to think this was a pretty good idea."

The next day Terry flew a demonstration with the commander of First Combat Applications Group, who came away wildly enthusiastic. Terry returned to Wright-Patterson and for a test bed was given a C-47, which proved an ideal platform: There were plenty of C-47s in Vietnam; they could carry large quantities of ammunition and flares, they could loiter a long time, and they could be converted back to a regular cargo aircraft if needed. The airplane had one disadvantage—it appeared vulnerable—but Terry knew C-47s had been operating for years as flare ships in Vietnam without undue losses and was not concerned.

A few months later, Terry got permission to take his findings and photos directly to Air Force Chief of Staff General Curtis LeMay at the Pentagon. Terry was planning to "talk about how effective the system would be attacking VC forces in the open

To take aim, the pilot had to maneuver the aircraft, not the guns, which were fixed in place.

USAF

before they got away" until he heard the intelligence briefing that immediately preceded him, and he decided on a new strategy. "The briefer was talking about a Viet Cong mortar and sapper attack on Tan Son Nhat [air base] that destroyed a lot of A-1s and killed a bunch of our people," Terry remembers. "LeMay had chewed through about three cigars listening to that briefing, so when it was our turn I told the guy I had brought with me not to show any surprise no matter what I said.

"I opened with, 'General LeMay, I'm here to brief you on a new concept for air base defense in Vietnam!' That got LeMay's attention. He listened and asked the three-stars what they thought—none liked it, except one general who said, 'General, this may revolutionize air warfare.' LeMay asked how many mini-guns there were. We told him there were nine prototypes and he said, 'Okay, take them to Vietnam and try it out.' We were on our way."

But unbeknownst to Terry, the program had powerful enemies in the Air Force who were apoplectic about using cargo aircraft for fire support, in part because of their rivalry with the Army. Air Force records show one message in which a four-star general complained to LeMay that the use of C-47s as gunships "was contrary to the Air Force's continuous and vigorous opposition to the Army equipping helicopters for fire control missions…[and] is tantamount to USAF approval for the use of all the Army's transport aircraft including helicopters for the same role." This message of opposition was also sent to the Air Force leadership in Vietnam.

Terry and his team landed in South Vietnam on December 2, 1964. He remembers, "We arrived at Tan Son Nhat and were met by a force of armed air police. They told us...we were not to talk to anyone and we and our equipment would be on the next plane back to the U.S."

But opposition to Terry's proposal did not sit well in Washington. In a curt reply to the general who sent the message, Vice Chief of Staff John P. McConnell (by then Chief of Staff designate; LeMay was to retire in a few months) told the general, "your concern is appreciated...[but] we cannot overlook or deny any weapon which will enhance our capability in this area of operation...[and] it is certainly in the Air Force interests to run the program rather than sit on the sideline commenting."

In Saigon the next morning, Terry received a copy of McConnell's message. "I kept it in my pocket the whole time we were there," he remembers. General Joseph Moore, commander of Air Force operations in Vietnam, invited Terry and his team to give a briefing, then gave his blessing to the project.

Using two C-47s from the First Air Commando Squadron, the men mounted 7.62-mm mini-guns on pods in the aircraft and began training a crew. On December 15 they went up for their first daylight mission with a crew of eight, including two pilots, two armament specialists, a loadmaster, an aerial photographer, a project engineer, and a Vietnamese observer.

The revamped C-47, now designated FC-47 (the "F" was for "fighter"), made its real mark on its first night flight on December 23-24 over the Mekong Delta, when the gunship was called to repel an attack on a U.S. Special Forces outpost. With the propellers whirling, the radio crackling, and guns at the ready, the loadmaster attached lanyards to large flares as the aircraft approached the target. After he threw them over the side, the flares drifted down into the darkness, suspended under small parachutes, to illuminate the area. Kimberlin vividly remembers: "We opened fire and it scared me half to death. I thought the guns had blown up. Flames not only came out of the muzzles but also blew back inside where they licked around the cans

An airman feeds clips into a 40-mm gun on an AC-130H.

USAF

U.S. AIR FORCE MUSEUM

where the spent cartridges were going. It was really noisy too, with the din from all three guns going '*brrrrrap*.' " The gunships poured 300 rounds a second into the attackers, every fifth bullet a tracer, and a three-second burst put 150 tracers in the air, giving the impression of "fire coming out of a watering can," says Kimberlin. The Viet Cong broke off the attack.

Kimberlin, who manned the guns on many FC-47 missions, remembers the unique dynamic among the side-firing aircraft's crew. The Vietnamese observer would "talk via radio to the people in the villages below that we were defending and tell them where the Viet Cong were." When an attack was under way, the flight engineer, who could see both the front and the back, manned a safety switch so he could turn off the guns in an emergency. Kimberlin also recalls a mission in which the loadmaster turned bombmaster by cutting the parachutes off the flares and dropping them directly into a plantation building where Viet Cong were hiding. The building burned to the ground.

The early missions were so successful that before tests were complete, Moore asked the Air Force for a full squadron of FC-47s as soon as possible. An Air Force report written a few months later said, "tests indicate spectacular success in killing Viet Cong and stopping attacks together with concurrent great psychological factor way out of proportion to effectiveness of other aircraft strike efforts and ground forces efforts." As an aside, in the course of their operations the FC-47 acquired two *noms de guerre*—"Puff, the Magic Dragon," from the Peter, Paul, and Mary song with that title, and a radio call sign, "Spooky."

The first combat use also showed that, while the aircraft took a few hits, the initial concern that the gunships would be exceptionally vulnerable to ground fire was unfounded. Mobile guerrilla forces attacking at night did not generally carry heavy machine guns; the guns they did carry were about the same caliber as the gunship's, but the ground forces fired up while the

While making a pylon turn, an AC-119 (also pictured below) traces a circle of fire, a pattern the Viet Cong called "dragon's breath."

COURTESY AIR FORCE MAGAZINE

RALPH KIMBERLIN

With members of the first AC-47 crew looking on, Captain Ron Terry (in hat) oversees the loading of ammunition for the 7.62-mm mini-gun.

BY MID-1969 IMPROVED VIET CONG defenses kept AC-130s out of some areas. Still, by April 1969 the Spectres had scored 42 percent of the truck kills in Laos while flying only 3.2 percent of the sorties.

gunship fired down, and this, combined with the fact that gunships operated at night, kept losses low.

The Air Force quickly took C-47s from the "boneyard" and began modifying them. By November 1965, 20 AC-47s (renamed A [attack], allegedly because of grousing from the fighter community) had arrived in Vietnam to form the Fourth Air Commando Squadron. The gunships protected Special Forces camps that the Viet Cong had been attacking almost nightly. Praise poured in. By the time the last American AC-47 mission flew, in December 1969, the aircraft had defended over 4,000 outposts. The crews accurately boasted that no position protected by an AC-47 had fallen.

Several of the AC-47s were sent to Laos for fire support missions and interdiction of North Vietnamese trucks coming down the Ho Chi Minh Trail, but while there were plenty of targets, there were also plenty of problems. Terry remembers, "The only way we could locate targets at night was to have a guy stand in the back door and look out. If he saw anything he'd say where it was—say, five o'clock—and the pilot would turn and line up his target visually.

"This proved very effective," says Terry, "but they had to be very low—as low as 1,500 feet—and the aircraft was heavily loaded and couldn't climb very well, so a bunch of planes literally flew into the high steep mountains." The heavier anti-aircraft defenses in Laos made the situation even more dire. Four AC-47s quickly disappeared without a Mayday call or a trace. The remaining gunships were immediately recalled to South Vietnam.

But the number of targets the AC-47s had found in Laos had convinced Terry—now a major—that the Air Force needed a more survivable gunship with increased firepower, night vision equipment, armor, a better navigation system, and a computerized fire control system for night interdiction of the Ho Chi Minh Trail.

The North Vietnamese used the trail, a huge complex of roads covering over 1,700 square miles, to move trucks at night, when they were safe from air attack, to resupply their forces in the south. The trucks were protected by a large number of anti-aircraft guns, 23-mm and 37-mm and a few 57-mm, manned by skilled crews. Interdicting the trail was a formidable task but a vital one.

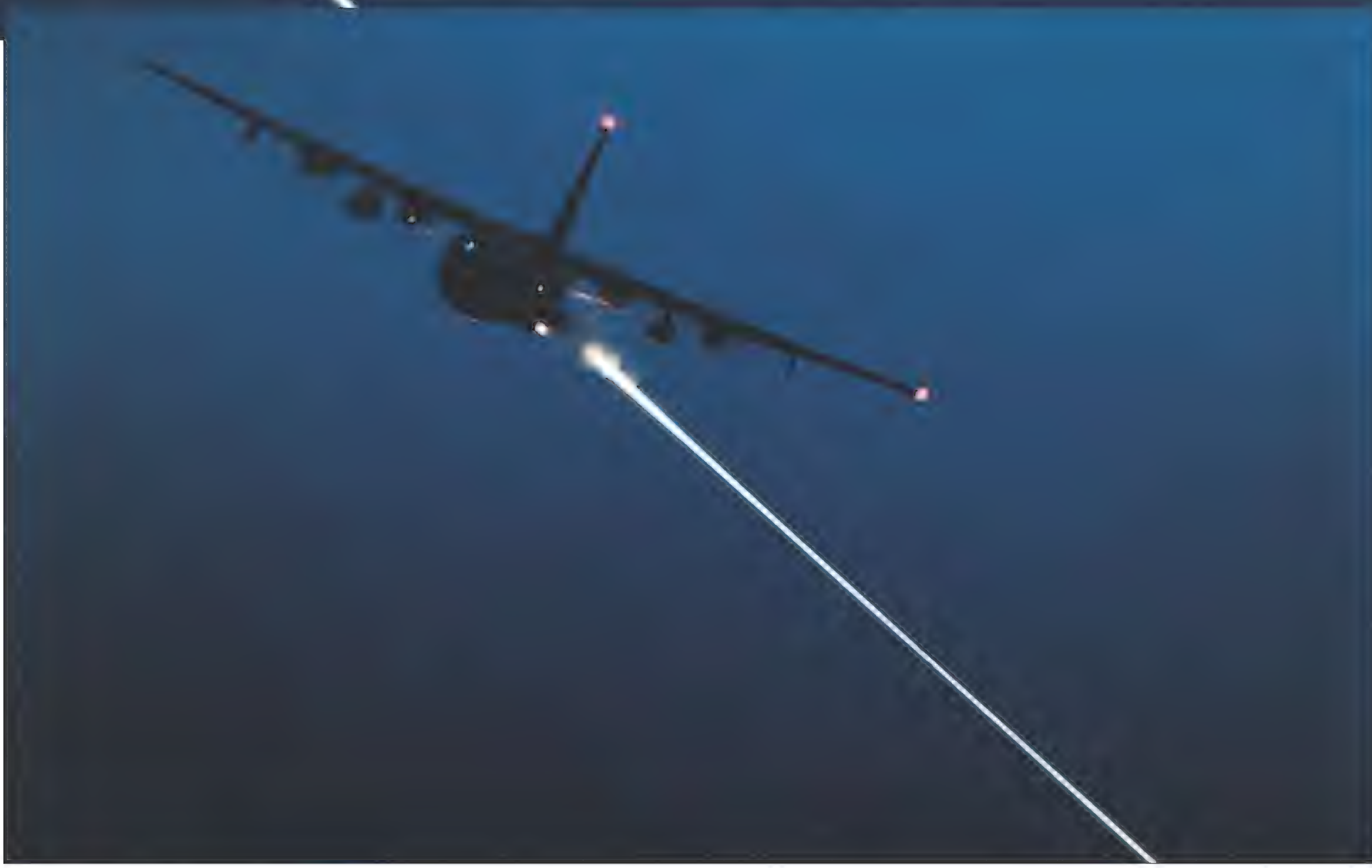
In January 1967 Terry got the go-ahead for a six-month project to modify a C-130A to carry night observation equipment, forward-looking infrared (FLIR), and side-looking radar, as well as two 20-mm Vulcan cannon and two 7.62-mm mini-guns, all of which were connected to an analog firing computer that took in all the sensor inputs to correct the pilot's side-looking sight for wind, airspeed, and attitude.

In September the prototype AC-130A arrived in Vietnam, with Terry as the lead pilot. On one of its first missions it knocked out eight trucks, and the aircraft—now named Spectre—quickly showed it was much more effective than any other night-attack aircraft. The Air Force ordered eight more C-130As modified into AC-130s, and at the same time modified cheaper, older, twin-engine C-119s into AC-119 gunships to supplement the AC-130s and AC-47s.

But while the AC-130s were decimating the North Vietnamese trucks, its new systems were proving unreliable. The Air Force sent the aircraft back to the States for some quick maintenance in February 1968, but rushed it back into service within weeks.

The North Vietnamese responded to the improved side-firing gunship by bringing more anti-aircraft guns into Laos. The gunships predictably attacked from a left banked turn, and under certain conditions they were visible from the ground—a quarter moon with high thin overcast made a gunship look "like a fly on a movie screen," one crew member recalls.

To watch out for anti-aircraft fire, a crew member was assigned to look out the right side away from the attack, while another crew member, the illuminator operator, literally hung out over the lowered cargo ramp in the rear, secured by cables to look out the back. Often an evasive maneuver



COURTESY AIR FORCE MAGAZINE

threw him out of the aircraft and he had to pull himself back in by the tethers.

Despite these precautions, in March 1969 the first AC-130 was hit and in May the first AC-130 was lost. By mid-1969 improved North Vietnamese defenses kept AC-130s out of some areas. Still, by April 1969 the Spectres had scored 42 percent of the truck kills in Laos while flying only 3.2 percent of the sorties.

In July 1969 and again in 1971, Ron Terry, now chief of the AC-130 program, made additional changes to the aircraft to counter the increasingly potent defenses. By March 1971 the Viet Cong had moved SA-2 radar-guided surface-to-air missiles into Laos. Dodging supersonic missiles at night over the high Laotian mountains in a four-engine aircraft was a daunting task. When a missile approached, the AC-130 had to dive down into the anti-aircraft environment, then struggle back up to altitude. That year, while no Spectres were hit by missiles, one AC-130 was downed by anti-aircraft fire and 33 were hit, some seriously.

In the never-ending quest for better armament, Terry replaced the 40-mm cannon he'd added to the 1969 model with a 105-mm howitzer. Approved under the name Pave Aegis, it arrived on February 17, 1972, and became an instant hit. The howitzer fired a 5.6-pound shell instead of the 40-mm's 10-ounce shell, was extraordinarily accurate, and had a very long range. When it hit, the shell gave a bright flash that other aircraft could use as a marker.

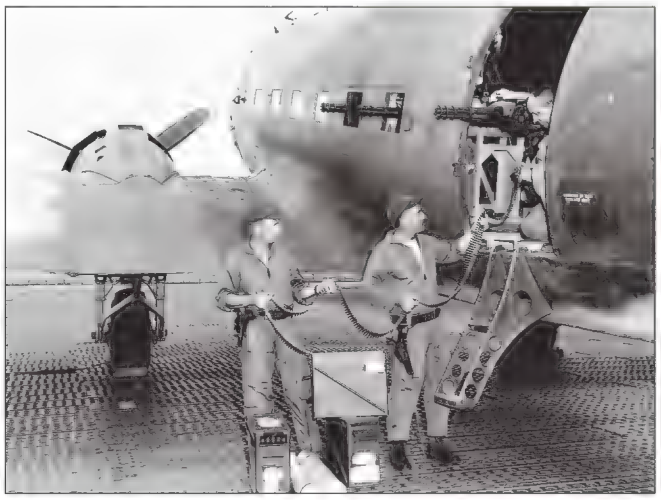
On March 31, 1972, the North Vietnamese began a massive offensive. For the AC-130s, interdiction became secondary as the gunships flew night and day close air support missions. The Viet Cong brought a new weapon with them—the shoulder-fired SA-7, the Saturday Night Special of surface-to-air missiles—which forced the gunships to a higher altitude, but the Spectres could still operate. On May 5, the day an SA-7 scored its first hit on an AC-130, another Spectre got credit for killing 350 enemy troops and saving 1,000 friendly forces.

By war's end, the gunship had made its bones, and Air Force chief of staff General John Ryan said: "We intend to keep this capability to deliver a tremendous volume of sustained accurate firepower in the tactical force."

In fact, that was not to be. The gunship had more bureaucratic battles to win before it was acknowledged as a genuine part of the U.S. military, but those post-Vietnam battles are another story.

With surgical precision, the AC-130H pinpointed targets, even enemy soldiers who had infiltrated friendly positions.

Ground crew reload ammunition for another Spooky run.



U.S. AIR FORCE MUSEUM

The Lone Star Observatory

IT MAY BE IN OKLAHOMA, BUT THIS AMATEUR-BUILT OBSERVATORY IS ALL TEXAS.

[by Eric Adams] Photographs by Scott Suchman]

IT'S A HOT AFTERNOON IN NORTH TEXAS. OPPRESSIVE HUMIDITY. BRIGHT SUNSHINE. LOTS OF BUGS. AFTER DRONING ON FOR MILES DOWN A SERIES OF WIDE, LONELY HIGHWAYS, WE STOP OFF FOR LUNCH AT A LOCAL TRUCK STOP, OUR EYEGLASSES INSTANTLY FOGGING UP AS WE CLIMB OUT OF OUR S.U.V. AND DROP DOWN ONTO THE DRY DIRT PARKING LOT.

Inside, we grab a table and continue talking about the sublime pleasures of looking at the night sky through a handmade, 24-inch-diameter telescope. We're likely the only ones in this particular restaurant talking about stars, galaxies, nebulas, and globular clusters. In fact, we're drawing glances. But Barry Smith, pipe always in hand, is an irrepressible sort, and the idea of showing off his pride and joy—the telescope he and 11 other big-thinking Texans spent over a decade designing, building, and perfecting—keeps him rolling exuberantly along amid the stern-faced truckers chowing down chicken-fried steak. Besides, Smith is the kind of guy who in 30 seconds could persuade these fellows to join us later for an evening under the stars.

Right now he's focused on getting his guests pumped up about tonight's viewing. He brags about the telescope's f/16 focal ratio, which determines the scale and quality of its images. (A focal ratio is a function of the mirror's shape and the length of the path the light travels after entering the instrument. A ratio of f/16 means that path is 16 times the mirror's diameter.) "There's magic at f/16," says Smith, jabbing his pipe stem toward us. "That's what our mirror designer said when we were designing the scope, and he was right. The images through this thing are so bright and so large. M57? Oh my God—it fills the field of view!"

Smith, who sells business jets for a living, is the de facto leader of a group of well-heeled amateur astronomers—doctors, engineers, and computer scientists among them—who decided a little more than a decade ago to pool their resources and build themselves an observatory. After years of site-scouting, countless weekend trips from the Dallas-Fort Worth area for construction efforts, many hours in the metal shop, and an investment of over $125,000, the group created the Lone Star Observatory, one of the finest ever

Some covet mountain lodges or beachfront condos, but this group's dream getaway has an 18-foot-long telescope.

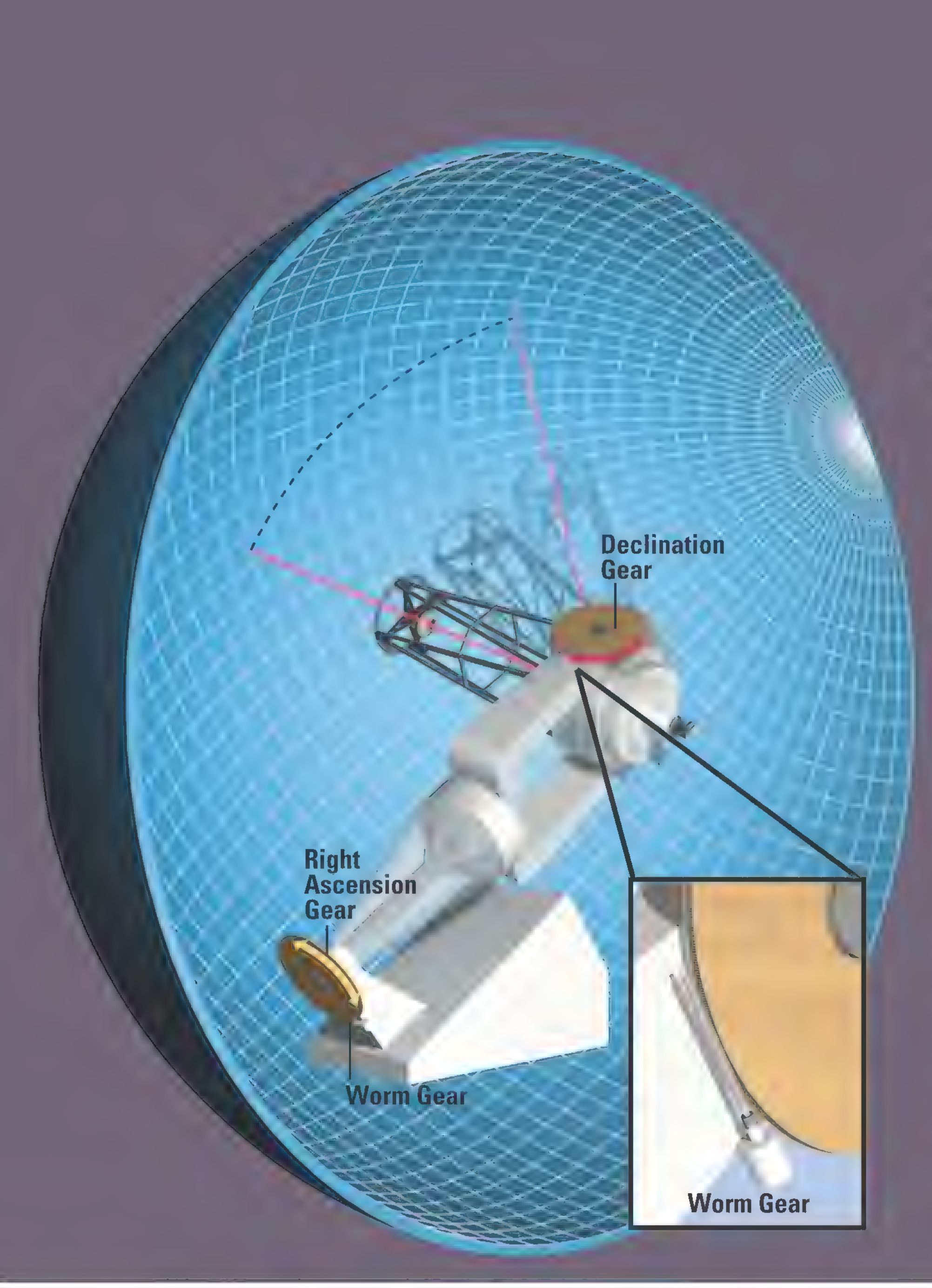
built by amateurs—and among the first of the amateur observatories to be completely computer-controlled.

We leave the truck stop and continue our journey, eventually crossing the state line into southern Oklahoma and entering the final leg, five miles of bumpy dirt road. Finally, we pull up to a 200- by 200-foot compound surrounded by a 10-foot-high chain-link fence topped with barbed wire. Inside are two buildings, one a small windowless rectangle and the other round and capped with a bright white dome.

Smith started seeking partners for the venture in the late 1980s among the customers of a small astronomy equipment shop he owned. "At the time I didn't really have the money," says Jack Hudler, a computer scientist, "but the project was so terribly interesting. He wanted to build an observatory, with a whole dome, in its own building—I love that kind of project. Then he pushed my button when he said he wanted to computerize it. That really hadn't been done before by amateurs."

The group began meeting to plan the project, and one thing quickly led to another. "We started out wanting to build a Volkswagen, and we ended up with a Mercedes," Smith says. "Each of us put in $3,000, and as we got farther and farther into the planning, we realized there were more and more things that we wanted. We would vote on something, it would pass, and we'd all put in more money." They agreed early on, for example, that they all wanted a separate clubhouse, with bunks, a kitchen and bath, and a living area in which they could come in to relax and cool off or warm up, since the observatory would have no climate control—telescopes need to be the same temperature as the outside environment, or air currents (warm air mixing with cool) will distort the images. They also wanted the scope to be a premium instrument with a rock-solid mount and a large-diameter mirror. The larger the mirror, the more light a telescope will collect and the brighter, more detailed the images in its eyepiece will be. Then, of course, there would be the computerization, the motorized dome, and a site far away from city lights to ensure dark skies.

While we wait for those dark skies to come, other members—Hudler, Jean Walker, Gary Mueller, and John Louden—straggle in. Some enter the clubhouse to go over star charts, read astronomy magazines, and catch up on one another's lives; others go to the dome to test the computers and get out all the eyepieces. (The optics in an eyepiece determine the magnification of the object in view. For Mars, which occupies a tiny point in the sky, higher magnification is desirable; for a nebula that spreads out over a large area, astronomers choose an eyepiece with lower magnification in order to see the entire object.) With its small air con-



Aiming for the Stars

The telescope's base is angled, so the shaft from the right ascension gear can be kept parallel to Earth's axis. That alignment helps the telescope to track various objects as they "move" across the sky.

Calibrated into millions of steps, the computerized gears can move the telescope in tiny (arc second) intervals. The computer plots each coordinate and then actuates the motorized worm gears (inset) to move the telescope.

ditioner working hard—it is clearly going to be needed throughout the night—the clubhouse is a cool, dim environment. Astrophotos and star maps hang on the walls, and the refrigerator in the galley kitchen is stocked with sodas and snacks.

Walker, a former political science professor who now describes herself as a "full-time volunteer," says she joined the group to have access to a large and sophisticated telescope. "Seeing the Whirlpool Galaxy for the first time in the telescope took my breath away," she says, clasping her hands together. "And I haven't lost any of that first experience. It's there every time."

Smith adds that trips to the observatory can soothe frayed nerves. "On a bad day, you can drive up here and stay for just two hours," he says. "There's something about getting out here for a little while—what you're worrying about just ain't very damn important. You can calm down and just relax."

Though amateurs have contributed important discoveries to the field of astronomy, most have no scientific agenda. Rather, they take pleasure in the learning process—studying galaxies, nebulas (gaseous remnants of exploded stars), and star clusters as they read about the objects. And of course they also enjoy what can be spectacularly beautiful sights. "Galaxies sometimes look like little puffs of cotton," Walker says. "Then you realize what you're looking at. Those are the things that give me chills."

Many members, though, do have well-developed observing programs, in which they study, for example, the intricacies of double stars (two stars that orbit each other), variable stars (which change brightness), or distant galaxies. The group's telescope is easy to use and has precision optics that show most major categories of celestial phenomena in great detail, so users can modify their programs as quickly as their interests change.

Bringing all this about took roughly three years, beginning with the site selection. The members found a dark site adjacent to one used by the Texas Astronomy Club, and they purchased the one-acre plot for $1,000. Construction began in 1988, with each member contributing some form of sweat equity. While some focused on the clubhouse, the rest worked on the concrete base on which the telescope would sit or the design and construction of the dome. "We had 12 well-educated professionals who've never built anything in their lives," Smith says. "The early part became a wonderful learning experience for all of us. I mean, just how do you build a round building with a rotating roof?"

They studied other observatories to get ideas and broke off into teams to research the computer controls, the mount, and the telescope itself. They finally decided on the design that was the easiest to maneuver, provided the most accessible eyepiece position, and gave them the best views: a classical Cassegrain, which uses a large primary mirror and a smaller secondary one that reflects the light back down through a hole in the center of the primary and into an eyepiece.

As the members laid foundations and framed the two buildings, Mueller, an engineer with an oil well pump manufacturer and one of the few knowledgeable about construction, worked out the design for the steel equatorial mount, which has two arms that hold the telescope between them and a base that is polar aligned—oriented parallel to Earth's rotation axis and angled to match the observatory's latitude, enabling it to more easily track objects as Earth's rotation causes them to appear to move across the sky. Then he built it. "We had a lot of extra room in the machine shop at work and some equipment that wasn't being used," Mueller recalls, "so I worked from five until 10 every night for a year to do it."

Meanwhile, Smith and some other members had found a renowned optical engineer, Jerry Brunache, who convinced them that a certain mirror design—24 inches in diameter and shaped to a focal ratio of f/16—would give them magnificent, large-scale images with few optical defects. As Brunache manufactured the mirror, Hudler worked on the computerization, which he had to invent as he went along. He obtained publicly available databases of sky objects to get coordinates for the computer's aiming software. It works by first determining where the telescope is pointed from the positions of its gears; then, using the coordinates of

the object to be studied, it calculates where the telescope needs to go. Hudler worked to get the software to accommodate a variety of variables, from built-in errors within the electrical motors to the flexing of the 17-foot-long telescope as it moves up and down. When the telescope began operation in 1990, he began testing the software by repeatedly selecting a particular star, slewing away from it, then checking to see if the computer could find the object again.

A number of refinements were necessary. "At first I didn't have a clue about how to correct these things," says Hudler, sitting cross-legged on the observatory floor and cleaning a telescope that is much smaller—though still one many backyard observers would cherish as their primary instrument—and that serves as a "finder" scope. "But trial and error and a lot of thinking helped me sort it out. When we fixed them, the computer started nailing every object."

When darkness falls, the user goes to the telescope's control center, a desktop computer, and selects what he or she wants to observe (using either common names—Ring Nebula, M31, etc.—or numbered catalog designations). The computer sends the telescope slewing to the proper position. A recent upgrade provides precise simulations on the computer screen of the eyepiece view, point-and-click aiming, and detailed information—size, magnitude, distance, composition—about all objects. Then the observer sits on a large, wheeled, stair-step chair to line up with the eyepiece and uses a hand controller to rotate the 20-foot-diameter, 21-foot-high dome so its narrow opening is lined up with the telescope. The controller also adjusts the focus and moves the telescope around without any computer assistance—usually for random cruising around the universe.

At the eyepiece, the images are indeed spectacular: wispy details in cloud-like nebulas, dark lanes in distant galaxies, and stars so faint that they are inaccessible to most telescopes amateurs buy. Globular clusters, in which thousands of densely packed stars appear as tight spheres, show stars resolved straight to the core. We are eager to see what the scope will reveal of Jupiter, Saturn, and Mars, which at this time of the year won't rise until after 3 a.m.

Each Lone Star member is entitled to sole use of the telescope a certain number of days per year. The rest of the evenings, such as this one, are open to everyone. The members often bring up school classes or scout troops, or individual young people interested in astronomy. This evening the members alternate at the eyepiece, taking time to discuss what they're seeing and what might be an interesting next target. When not at the eyepiece, they stretch out on recliners on the observatory's deck to enjoy the sky and chat. "I've always marveled that we were able to put this thing together without much disagreement," Hudler notes. "Nerves got frayed a couple of times, but decorum was kept at a professional level."

Inside the clubhouse, the lights, instead of the customary white, are a dim red, which helps preserve essential night vision. Even the refrigerator is equipped with a red light, to eerie effect—when you open the door, the light renders the Coke cans virtually invisible.

At about 2:30 a.m., we turn in for a two-hour nap, then get up to observe Jupiter and Saturn, which by then have risen in the east. Unfortunately, the early morning has also brought in a thick haze, and the sky is virtually impenetrable. Jupiter and Saturn are both disappointing—revealing about as much detail as you would get with an average backyard telescope under ideal conditions. "This is part of the risk," Walker says. "The weather can completely turn on you."

But all is not lost. As we gather outside, a bright meteor streaks across the sky, breaking into chunks that leave long, dramatic trails.

Later, as we all leave for breakfast, the members invite the visitors to return. You can't see the universe in only one night.

John Louden scans the skies in the usually darkened dome (right), while Jack Hudler, the group's computer specialist, tests the telescope's aiming software (below).

It took 28 seconds for USAir Flight 427 to plummet from the sky. It took the National Transportation Safety Board five years to figure out why.

PROBABL

Flight 427 virtually disintegrated on impact.

E CAUSE

AFTER USAIR FLIGHT 427, A BOEING 737-300, CRASHED OUTSIDE PITTSBURGH ON SEPTEMBER 8, 1994, *St. Petersburg Times* reporter Bill Adair was granted unprecedented access to the National Transportation Safety Board's investigation. Boeing claimed the crash—which killed all 132 people on board—was caused by pilot error; the pilots' union claimed the Boeing 737 was defective.

When the investigation concluded in March 1999, Adair published a vivid four-part narrative in the *St. Petersburg Times*. An expanded account of the investigation, including the players and politics involved, was published in April 2002 by Smithsonian Institution Press in the book *The Mystery of Flight 427*. In this excerpt, investigators zero in on a suspicious servo valve in the power control unit, a hydraulic device that controls the movement of the rudder.

by Bill Adair

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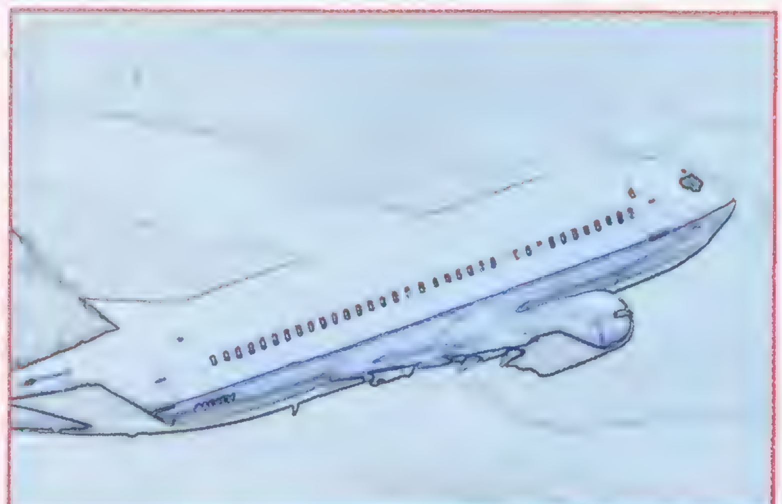
A hydraulic valve had to pass a battery of tests to get accepted by Boeing. One test shook it violently, like a can of house paint in a mixer. Another test moved the valve back and forth five million times. The most brutal test froze the valve to –40 degrees Fahrenheit and injected it with hot hydraulic fluid. That represented the worst imaginable condition—a hydraulic pump overheating when the plane was in frigid air at 35,000 feet. Hot fluid would shoot into the frozen valve, causing it suddenly to expand. The test was called thermal shock.

Boeing didn't manufacture the valves, just as it didn't build most of the parts for its planes. Instead, it relied on hundreds of suppliers such as Bendix Electrodynamics. In 1966, the company was bidding to make a similar hydraulic valve for for Boeing's giant new plane, the 747. Bendix engineers built a prototype of the valve to undergo the standard battery of tests—the paint shaker, the marathon, and thermal shock.

The tests for the 747 valve were conducted in a gray stucco building in an industrial section of North Hollywood, California, not far from the Burbank airport. The lab, which took up most of the first floor, was filled with a thick, oily smell from all the hydraulic fluid. The room was a veritable torture chamber for a hydraulic valve. The lab even had special steel containers called crash boxes that were used the first time a valve was pressurized, in case it exploded.



RUSSELL MUNSON

"I think we should look at this," Vick told Phillips. "It may be something."

Upstairs was a man named Ralph Vick, an engineer who worked on some of the company's most important projects. Vick was not directly involved in the bid for the 747 valve, but he kept close tabs on the tests because he—like everyone else in the company—desperately wanted to win the big Boeing contract.

The torture tests on the 747 valve were no different from hundreds of others performed in the Bendix lab that year. The technicians placed the valve in a tiny freezer and hooked up the hydraulic lines. Once the valve had cooled to subzero, they flipped a switch and heard the steady whine of the hydraulic pumps. They moved the valve back and forth, as if a pilot were stepping on the pedals. Then someone flipped another switch, and piping hot fluid shot inside. Usually the valve kept moving. But this one strained and then stuck for a few seconds.

It had failed the test.

When Vick heard about the results, he knew it was a setback but didn't think it was a catastrophe. The valve was an amazingly tight device, with only a few millionths of an inch between each slide, so a very tiny design error could cause a jam. The Bendix engineers went back to their drawing boards and redesigned the tolerances. The new valve passed without problems.

Thirty years later, Vick unpacked his suitcase in his L'Enfant Plaza Hotel room in Washington, D.C., and sat down at the desk with a legal pad. He had come to Washington for the first meeting of the "Greatest Minds in Hydraulics," a title selected by lead NTSB investigator Tom Hauter, to review the work of the National Transportation Safety Board on the Flight 427 case. The safety board had hit so many dead ends in the case that the panel had been assembled to look for new tests that the investigators should try. At 67, Vick was a quiet, serious man, a good choice for the group because he had designed dozens of valves and had been awarded 25 patents. He was quite familiar with the unique valve-within-a-valve used for the 737 rudder.

Sitting in his hotel room, he recalled the Bendix test 30 years earlier, when hot fluid hit cold metal and the prototype valve stuck for a few seconds. That jam turned out to be no big deal—a redesign took care of the problem. But he wondered if the rudder valve on the USAir plane had stuck the same way. He sketched a brief outline of the test on a piece of paper and gave it to NTSB investigator Greg Phillips the next day.

"I think we should look at this," Vick said. "It may be something."

The NTSB had not done a thermal shock test on Flight 427's valve because there had been no comments on the cockpit tape about a hydraulic problem. If one of the pumps had broken, it would have triggered a warning light in the cockpit and the pilots would likely have mentioned it. But Phillips agreed to try the test. He was open to any suggestion.

The power control unit recovered from the USAir crash, manufactured by Parker Hannifin, would be frozen to –40 degrees, similar to the outside temperatures at 30,000 feet, and then would be pumped with hot hydraulic fluid.

No one expected a breakthrough. The 737 valve had passed its own thermal shock test when it was certified in the 1960s. Besides, Boeing officials said the temperature range was far more extreme than anything the PCU encountered in real life. Boeing viewed the test as a waste of time. Boeing's Jean McGrew, chief engineer for the 737, said the airplane would encounter thermal shock conditions only if it flew to the moon.

Adapted from *The Mystery of Flight 427: Inside a Crash Investigation* by Bill Adair, Smithsonian Institution Press, April 2002.

> THE VALVE was an amazingly tight device, with only a few millionths of an inch between each slide, so a very tiny design error could cause a jam.

On August 26, the Greatest Minds in Hydraulics and Phillips' systems group gathered at Canyon Engineering, a tiny hydraulics company in an industrial park in Valencia, California. They had chosen Canyon because the chairman of the hydraulics panel worked there, but the company did not have the sophisticated test equipment that Boeing and Parker Hannifin, the unit's manufacturer, did. Phillips brought the PCU in a sturdy navy blue chest, like a violinist carrying his prized Stradivarius. He took the 60-pound case to his hotel room each night to make sure that no one could tamper with the device.

At Canyon, the PCU was placed in a big white Coleman cooler, the kind you take on a picnic. Holes were cut in the cooler for pipes and tubes and then sealed with gray duct tape. John Cox, the pilots' union representative in the investigation, and several others in the room said they were concerned that the temperatures were not controlled closely enough to produce legitimate results. But they forged ahead with the tests to see what would happen.

The group tested two PCUs—a new one straight from the factory and the one from the crash. To make sure that the hydraulic fluid was similar to Flight 427's, they used fluid drained from other 737s. They used a pneumatic cylinder to act like the pilot's feet, pushing the valve back and forth. The room filled with a steady rhythm of clicks and hisses as the cylinder moved the valve left and right.

Click, hiss, click, hiss. They put the factory PCU through its calisthenics at room temperature, testing it 50 times. It responded normally. They let gaseous nitrogen into the cooler and watched the temperature gauges plummet to –30 or –40 degrees to simulate the air at 30,000 feet. *Click, hiss, click, hiss.* Finally, they tried two tests to simulate an overheated hydraulic pump, heating the fluid to 170 degrees. *Click, hiss, click, hiss.* The hot fluid hit the cold valve, but there were no problems. The factory PCU worked great.

They removed it from the Coleman cooler and installed the PCU from Flight 427. *Click, hiss, click, hiss.* No problems at room temperature. *Click, hiss, click, hiss.* The frigid unit was blasted with hot fluid, but it still worked fine.

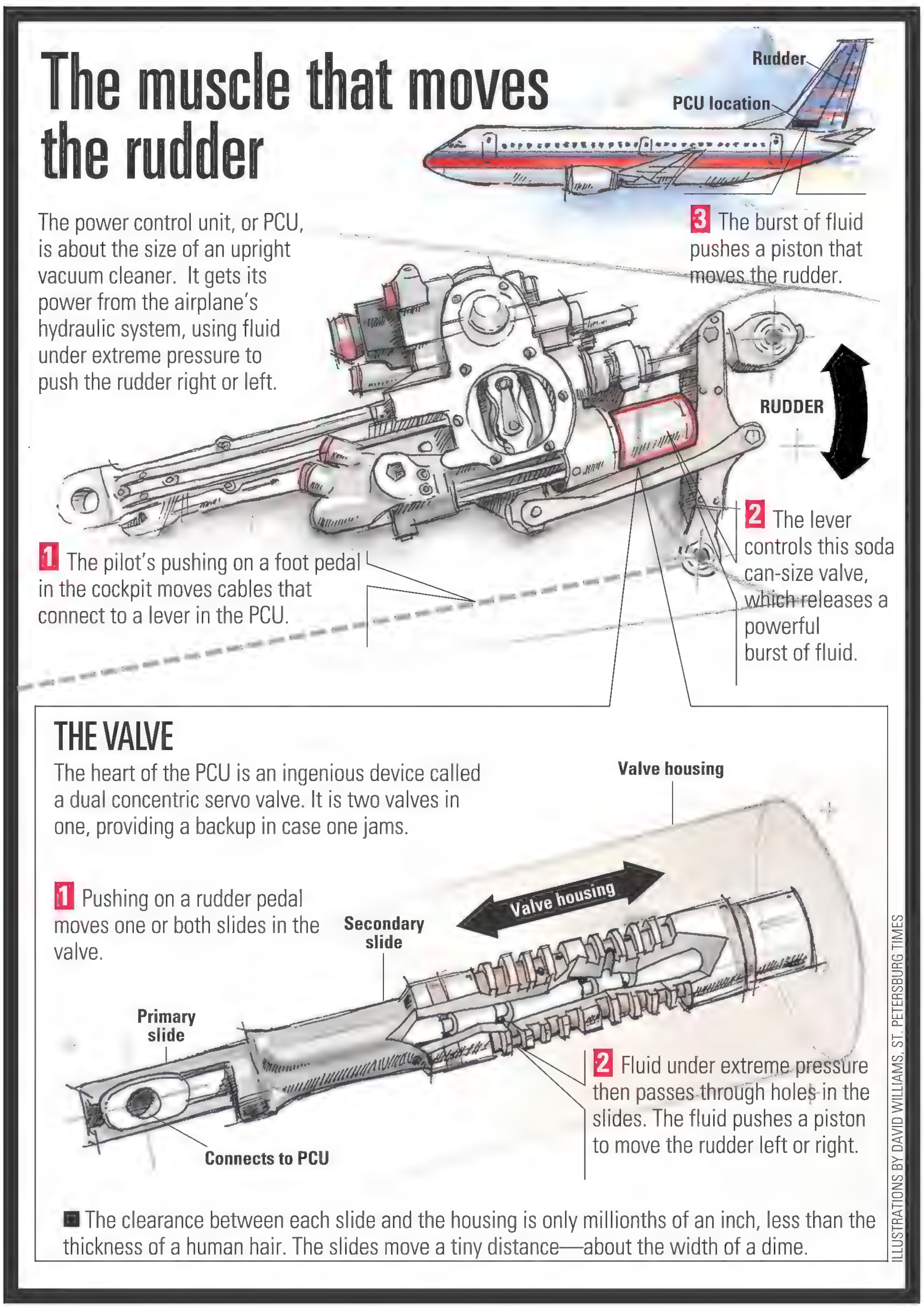
It was the investigators' last day in Valencia, and the tests were going so smoothly that several people started to pack up and say goodbye.

They had reached the most extreme condition. The PCU was depressurized, frozen with the nitrogen gas, and then injected with piping-hot fluid.

The hot fluid hit the cold valve. *Click, hiss, click, hiss, click, hiss, click, hisssssssssssssssssss.*

The hissing changed pitch. The valve had jammed.

"It didn't come back," said someone in the room.



IF HE WAS RIGHT, it meant the PCU was not performing the way Boeing had promised. The valve-within-valve was supposed to provide redundancy if one slide jammed. But this meant that a single jam could cripple a plane.

"That's interesting," said someone else. "Reeeeaaalllll interesting."

A second later, the arm went back to neutral and began cycling again. *Click, hiss, click, hiss.*

They stopped the test and talked about what had happened. Did they have a breakthrough? The test conditions were so poorly controlled that any result was questionable. A computer operator who had been collecting test data had mistakenly deleted everything, so the team had little evidence of what they had seen. Everyone agreed to try it again.

Click, hiss, click, hisssssssssss. Click, hisssssssssss. The valve was moving slower than it was supposed to. *Click, hissssssssssssssssssssssss.* It stuck again.

The group agreed that the test should be done again in a more controlled setting. The Boeing team criticized the tests, saying they were too extreme and that the valve could have been damaged. So the next morning, Phillips woke up at 4 a.m. and drove to Parker Hannifin in order to perform a test to make sure the valve was okay.

The test was crucial. When the group had first examined the valve after the crash, they had not found any scratches inside it. If they found scratches now, it would prove that a jam had occurred, which would indicate there had not been a jam on Flight 427. Also, a scratch would mean that the valve had been altered since the crash, which would rule out further tests. The whole theory about a valve malfunction would go down the drain.

The Parker technicians took the valve apart, measuring and documenting each piece. They put them under a microscope, examining each surface for scratches or scrapes. They found none and no evidence of a jam. Phillips breathed a sigh of relief.

They had proved that the valve could jam—and leave no evidence behind.

Six weeks later, Phillips' group reconvened in a Boeing laboratory in Seattle. This time, instead of testing the PCU in the Coleman cooler, they used a specially designed foam box with a window on top. The box's cooling system was more powerful and precise, with temperatures closely monitored by a computer.

They ran through the same tests they had done in Valencia, starting with the factory PCU at room temperature and then trying a variety of thermal shocks. Once again, the factory PCU passed every test.

The technicians removed it and replaced it with the PCU from Flight 427. It passed the first tests with no trouble. Then came a repeat of the most extreme test in the Coleman cooler. They removed hydraulic pressure from the PCU and let it soak in the cold air until it reached –40 degrees. The hydraulic fluid was heated to 170 and shot directly into the PCU. The technician moving the valve back and forth felt it slow down. He didn't notice it bind, but a computer showed it had jammed momentarily. He repeated the action, and felt the lever kick back when he tried to move it to the right. When he tried again, he felt it stick to the left and then jam.

Once again they had shown that the 427 valve was unique. It jammed when the factory unit did not.

Yet Boeing was right. The extreme temperature range necessary for a thermal shock just wasn't present in real life. And there was no proof that ther-

USAir pilot John Cox (left) and NTSB investigators Greg Phillips (below left, with rudder valve) and Tom Haueter (below) were part of a team of driven aviation detectives.

BILL SERNE, ST. PETERSBURG TIMES (3)

mal shock had occurred on the USAir plane. Despite their skepticism, Boeing engineers said they would examine the charts from the tests for anything unusual.

A few days later, in a building overlooking Paine Field in Everett, a young Boeing engineer named Ed Kikta sat at his desk, reviewing the charts. He could see the test data on his computer screen, but he liked to print the results so he could study them more closely. The charts showed the flow of hydraulic fluid during each test: higher when it was pushing the rudder and down to zero when it was not. Kikta expected that when the outer valve jammed during the thermal shock, the inner valve would compensate and send an equal amount of fluid in the opposite direction, which would keep the rudder at neutral. That was the great safety feature of the 737 valve. It could compensate for a jam.

But as Kikta studied the squiggly lines for the return flow, he saw dips that were not supposed to be there. When he matched them to another graph showing the force on the levers inside the PCU, he made an alarming discovery. When the outer valve had jammed, the inner valve had moved too far to compensate. That meant the rudder would not have returned to neutral, the way it was supposed to.

The rudder would have reversed.

That could be catastrophic. A pilot would push on the left pedal, expecting the rudder to go left, but it would go right.

To make sure he hadn't made a mistake, Kikta showed the results to the other engineers in the room. They agreed with his interpretation. It appeared that the valve had reversed. Kikta looked up and saw that his boss, Jim Draxler, was putting his coat on, getting ready to leave. Kikta stopped him.

"I think I've found something in the data," Kikta said. "We might have a problem here." Draxler took his coat off, set down his briefcase, and listened to what Kikta had to say. The consequences of his discovery were enormous. If he was right, the PCU was not performing the way Boeing had promised. The valve-within-a-valve was supposed to provide redundancy if one slide jammed. But this result meant a single jam could cripple a plane.

The next morning Draxler convened a group that he called his "grizzled veterans," engineers who had lots of experience with flight controls. Kikta explained his findings and showed them the charts. Draxler went around the room, asking each engineer about the significance of Kikta's discovery. They were unanimous: It was a serious problem that needed to be fixed quickly.

RUSSELL MUNSON

Engineers usually needed weeks to get an airplane for a test, but now they got one off the assembly line in just 24 hours.

Boeing sprang into action. The company ordered Parker Hannifin to run its own tests to check Kikta's conclusions. Parker engineers confirmed the results and discovered that when they jammed the outer valve, the levers in the PCU appeared to flex slightly, which allowed the inner valve to line up with the wrong holes.

Boeing was notorious for being the slow-moving "Lazy B," but not this time. Fear was a powerful motivator. Engineers usually needed weeks to get an airplane for a test, but now they got one off the assembly line in just 24 hours. The plane landed at Boeing Field and was pulled into a company hangar. As a cold rain fell outside on the night of October 29, 1996, the 737 was rigged with the special device that Parker had built to simulate the jam. Michael Hewett, a Boeing test pilot, climbed into the cockpit while Kikta stood on a platform on the tail of the plane, watching the rudder and the PCU. Hewett pushed on the pedals, moving the rudder from side to side. The first two tests went smoothly, and the rudder operated as intended.

Then came a more rigorous test. Hewett slowly stepped on the left pedal and the rudder moved properly. He then jammed his foot on the right pedal as hard as he could. It kicked back with tremendous force.

The rudder swung in the wrong direction.

Further tests showed that the likelihood of the rudder reversing depended on where the outer slide jammed. If it jammed closer to its neutral position, the rudder was less likely to reverse. But if it jammed when it was farther from neutral, a reversal was more certain.

It was about midnight now and everyone was exhausted. They all drove home worrying about what they should do to fix the plane.

The next day, Boeing notified the FAA that the company had found a problem with the rudder PCU but wanted 24 hours to figure out how to deal with it. The FAA agreed.

Intense meetings went on all day in Renton and Everett, Washington, as the Boeing engineers discussed how to respond. They broke into two teams, one to come up with a plan to enable pilots to detect and respond to a jam, and another to look at long-term design changes to the PCU. They worked into the night. By 11 p.m., they got approval from senior management for a pilot test and some short- and long-term changes to the PCU.

The next day, Halloween, about 10 Boeing officials drove to the FAA office in Renton, a big mirrored cube of a building beside Interstate 405. They weren't sure what the FAA would

do. Would the agency want to ground the airplane? The PCU no longer protected against jams the way it was supposed to, so the plane might no longer meet certification standards.

About 25 Boeing and FAA officials gathered in a conference room. Draxler began by explaining what they had found in the tests, with Hewett frequently interrupting to give his perspective. It took a unique kind of windup to trigger the phenomenon, they said. You had to press on one pedal and then stomp hard on the other to make the primary slide line up with the wrong holes and cause the reversal.

An FAA official asked: Did this match what had happened to the USAir plane?

The Boeing engineers said that all they knew from the test was that if you jam the outer slide, you could get a reversal. Jams were extremely unlikely because of the many filters in the hydraulic system, which removed particles before they caused problems. In 30 years and more than 50 million flights, there had been only seven confirmed jams. None had resulted in an accident or injury. And there was no evidence that one had occurred on the USAir plane.

Another FAA official pointed out that the new evidence seemed to counter Boeing's claims that the pilots had caused the crash.

Jean McGrew spoke up. "We've received a lot of public criticism about hiding things and not wanting to spend a lot of money," he said. "But I frankly don't care [what it costs]. If there is something wrong with the airplane, I want to fix it."

The meeting ended. Boeing said it would issue a bulletin to warn airlines about the condition. The bulletin would require mechanics to perform a test every 250 hours, stomping on the pedals to check for jams. The FAA planned to issue an emergency airworthiness directive that mandated the tests. Boeing also said it would develop a long-term plan to redesign the valve to prevent a reversal. That fix was likely to take several years.

These emergency directives were more symbolism than real action, designed to reassure the public that the FAA was taking action. The engineers knew the tests would not be very effective. They would catch a jam if it occurred at the precise moment of the test, but a jam could still occur at any time.

Despite Boeing's discovery, FAA officials say they did not give serious thought to grounding the 737 fleet. The plane had a good safety record, they said, and a jam was still considered highly unlikely.


RUSSELL MUNSON

The bulletin would require mechanics to perform a test every 250 hours, stomping on the rudder pedals to check for jams.

While the Boeing-FAA meeting was going on in Renton, Phillips and Tom Haueter were 2,000 miles away in Pittsburgh, unaware of the developments. They had returned to the Holiday Inn near the Pittsburgh airport to meet with all the parties. Haueter and each of his group leaders gave updates on the investigation. Phillips reviewed the results of the thermal shock tests (without knowing of Boeing's finding) and discussed what work still needed to be done. Rick Howes, the Boeing coordinator for the investigation, sat through the all-day meeting without saying a word about the company's big discovery.

When the meeting broke up, Haueter, Phillips, and Tom Jacky, the NTSB performance chairman, took a flight back to Washington. As they got off the plane at National Airport and walked toward the subway station, Haueter's beeper went off. The NTSB had a new pager system that could transmit words as well as phone numbers.

Haueter glanced down at it. "major finding rel to pit / defect found on servo valve," the pager said.

"This is a joke," he said. "This isn't real. Some jerk has figured out our paging system." They went their separate ways and headed home.

The message had come from Ron Schleede, Haueter's boss, who had been working late in the NTSB office when McGrew and John Purvis, the head of Boeing's accident investigations, called to tell him about the finding. Schleede transmitted the message to Haueter and then walked downstairs to the bar at the L'Enfant Plaza Hotel, where NTSB chairman Jim Hall was having a drink.

"Jim," Schleede said, "I think we've got it."

The next day, the FAA briefed Haueter, Phillips, and other NTSB officials about the finding. Haueter realized that it was a major piece of his puzzle.

"This isn't the way I thought it would end," he told Phillips as they walked back after the meeting. "I expected it was going to be a fight all the way to the end, putting all these little pieces together, with people saying we wouldn't have enough evidence. And all of a sudden here is something no one expected."

That day, Boeing sent a telex to every airline in the world that flew 737s:

Alert Alert Alert Alert Alert Alert Alert
Boeing Alert Service Bulletin 737-27A1202
November 1, 1996.

EVERY RUDDER VALVE was slightly different. All valves had to meet Boeing and FAA standards, but none of the holes for hydraulic fluid on each one were exactly the same. The tests so far suggested that some valves could be more prone to reverse than others.

The dual servo valve is designed to overcome the effects of a jammed primary or secondary slide. Although there has never been a report of a secondary slide jam, tests just completed at Boeing have shown that, under certain conditions, some jams of the secondary slide can result in anomalous rudder motion.

Anomalous rudder motion: It was a Boeing euphemism for a catastrophic situation—a rudder jam and a reversal.

John Cox of the Air Line Pilots' Association heard rumblings about the discovery on Halloween night but didn't hear the news until the morning of November 1, when the alert was issued. He had spent an extra day in Pittsburgh and was summoned to the office of William Barr, USAir vice president of flight operations. A group of pilots and safety officials were meeting to discuss the service bulletin and how USAir should respond. The airline had the third-largest fleet of 737s in the world.

Barr asked Cox point-blank, "Is the airplane safe?"

"Yes," Cox said. He was convinced that a jam was still highly unlikely and that, even if one occurred, pilots could recover. USAir had been the first airline to raise its minimum speed above 190 knots (220 mph), an increase that enabled the pilot to counter a rudder hardover by turning the wheel; therefore, USAir pilots had an extra cushion of safety. And the airline's pilots were already doing a rigorous rudder check, so they were effectively conducting the test before every flight.

Cox was convinced that a jam was still highly unlikely, and that even if one occurred, pilots could recover.

Just before Thanksgiving, Phillips went back to the Parker plant in Irvine to compare the valve from the USAir plane with the ones from an Eastwind Airlines 737 that had had a rudder anomaly and the factory PCUs. He wanted to find out if there was something that made the Flight 427 valve jam when the others would not.

Every rudder valve was slightly different. All valves had to meet certain Boeing and FAA standards, but none of the holes for hydraulic fluid on each one were exactly the same. The tests so far suggested that some valves could be more prone to reverse than others.

At Parker, the three valves were each disassembled and examined and then hooked into a test rig to see how far off neutral they had to be moved before the rudder would reverse. The factory valve performed the best. It would not reverse until the outer slide was 38 percent extended. But the USAir and Eastwind valves would reverse more easily, when the slides were extended 12 and 17 percent, respectively. Also, a measurement of the distance between the valve slides found that the USAir unit was considerably tighter than the other two.

That was the final piece of evidence that Haueter had waited for. At last he had proved that the USAir valve was unique. After three years and hundreds of tests, he now had a scenario for what had happened to Flight 427.

It went like this: It was a smooth flight from Chicago to Pittsburgh, so there was not much movement of the yaw damper, which automatically moves the rudder to compensate for the onset of yaw. That lack of movement might have allowed particles to build up in the hydraulic fluid. There could have been a modest thermal shock to the PCU because of overheated fluid from a hydraulic pump—not enough to set off a warning to the pilots but enough to make the cold valve suddenly expand.

The PCUs on other 737s might have tolerated that without trouble. But the valve on this particular USAir plane was especially tight. The thermal shock and the contaminants caused a jam. And the jam happened when one slide inside the valve was slightly off center and more likely to reverse. The pilot or the yaw damper was commanding the rudder to go right, but it went hard over to the left.

All of this occurred at the most vulnerable speed for a 737: 190 knots, when a rudder hardover could not be overcome by turning the wheel. The pilots compounded the problem when they pulled back on the control column, which made the plane lose speed and stall. The plane spiralled down and crashed into a hill.

It always takes a chain of events to cause a crash. In this case, it took wake turbulence from a Delta 727 that had been flying ahead of Flight 427, the startling of the pilots, the fact that the plane was flying at the crossover point, the uniqueness of the valve, the jam and reversal, and the mistake of pulling back on the control column. If any one of those things had been different, the plane would not have crashed.

"What the hell is this?" Captain Peter Germano had said on the cockpit voice recorder as USAir 427 plunged toward the ground. Haueter thought he finally knew the answer.

How Things Work: Ejection

by Mary Collins | Illustrations by John MacNeill

Last December, when an airman on a mission to Afghanistan initiated the ejection sequence on a B-1 bomber that was going down over the Indian Ocean, all four crew members blew out of the airplane in less time than it takes you to read this paragraph.

They ejected at four different times and at four different angles so they wouldn't hit each other while clearing an airplane that, crippled by "multiple malfunctions," was going more than 600 mph at 15,000 feet.

"It was the most violent thing I've ever felt in my life," says one of the B-1 crew members, whom the Air Force asked me to identify as "Captain IROC." "I lost a full inch in height," because his spine absorbed such tremendous G-forces.

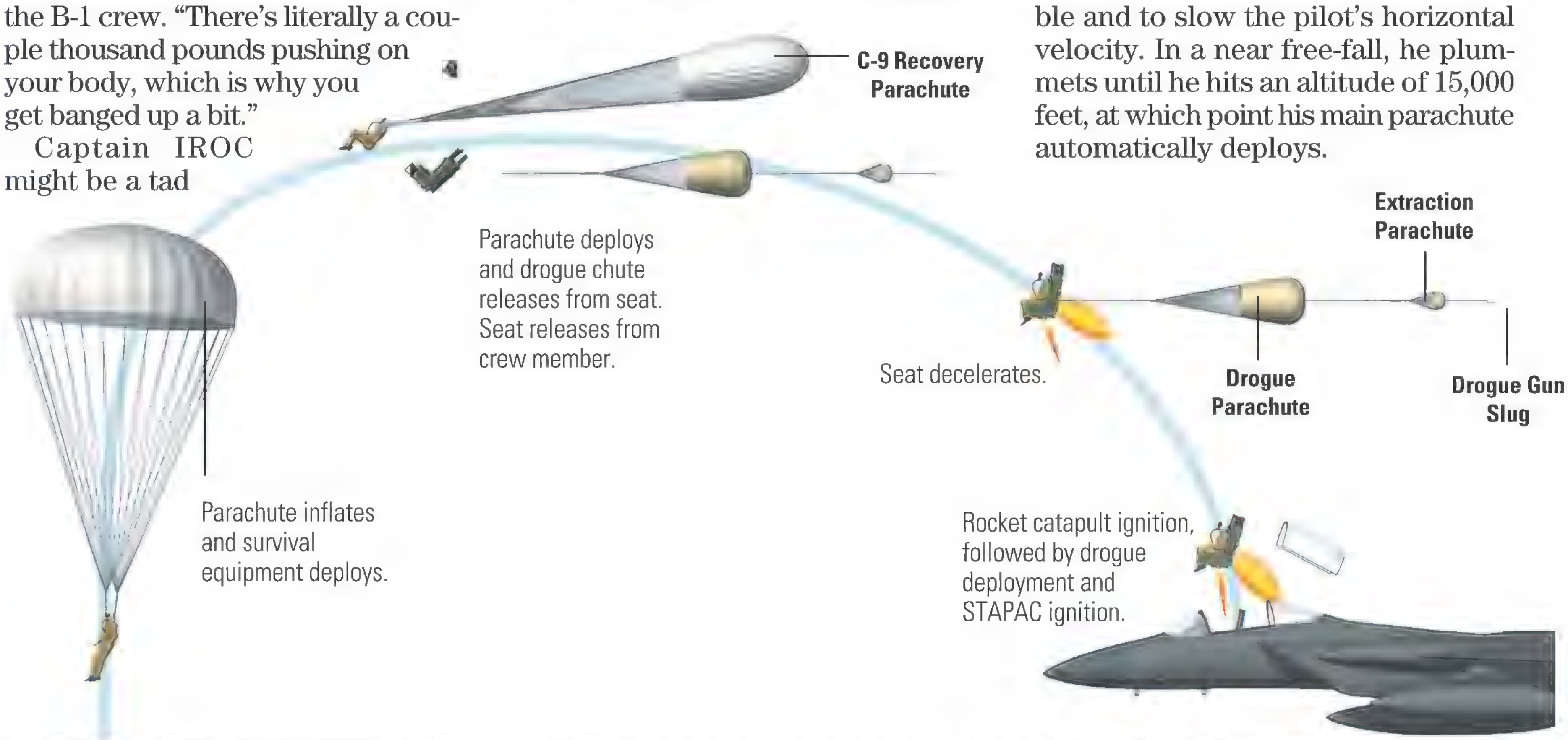
"At 600 mph there's tremendous aerodynamic pressure pushing down on you," says John Hampton, engineering manager of the Goodrich ACES II ejection seat, the model that saved the lives of the B-1 crew. "There's literally a couple thousand pounds pushing on your body, which is why you get banged up a bit."

Captain IROC might be a tad shorter, but he's still around to chat. Here's why.

When a pilot pulls his ejection seat's handle, which is located either between his legs or on one or both sides, depending on the cockpit arrangement, an electrical pulse signals thrusters to unlock the hatch, then rotate it up and out into the air stream. In the case of the B-1, the explosion ripped open four hatches, one for each crew member.

Two pitot tubes (one for backup) on the side of the seat measure aerodynamic pressure to assess the speed of the airplane. A port behind the seat back measures ambient air pressure to determine the altitude. A central processing system—either digital or analog—takes this data and makes a calculation to determine which of three possible modes to activate. (Navy fighter jet seats, like the Martin-Baker NACES, can have up to five options.)

Airplanes flying at low altitudes and low speeds will use a different sequence from that of jets flying at high speeds and high altitudes. For example, F-22s, which use the ACES II seat, will sometimes cruise at 50,000 feet, where there's not much oxygen. The seat supplies supplemental oxygen, but because the pilot needs to get down to thicker air as rapidly as possible, the main chute doesn't open right away. Instead, a smaller chute called a drogue deploys to stabilize the seat so it doesn't tumble and to slow the pilot's horizontal velocity. In a near free-fall, he plummets until he hits an altitude of 15,000 feet, at which point his main parachute automatically deploys.



Seats

STAPAC System

At low altitudes a pilot doesn't need to free-fall, so the main parachute opens immediately and the drogue stays in its case. All of the decisions based on speed, altitude, and the weight of the passenger are already made for the pilot before he even clears the aircraft.

Manufacturers have spent decades perfecting all the steps necessary for a fully automated ejection. A hole blows open overhead. The wind surges in. The pilot can feel the chemical cartridge ignite under his seat, which activates a catapult that pushes his seat up a rail. One-tenth of a second after yanking the handle, he's out of there. As he clears the airplane a rocket system called STAPAC kicks in. The wind wants to flip the seat around like a milkweed seed, but the thrust from STAPAC offsets the rotation and keeps the seat and pilot upright and forward facing.

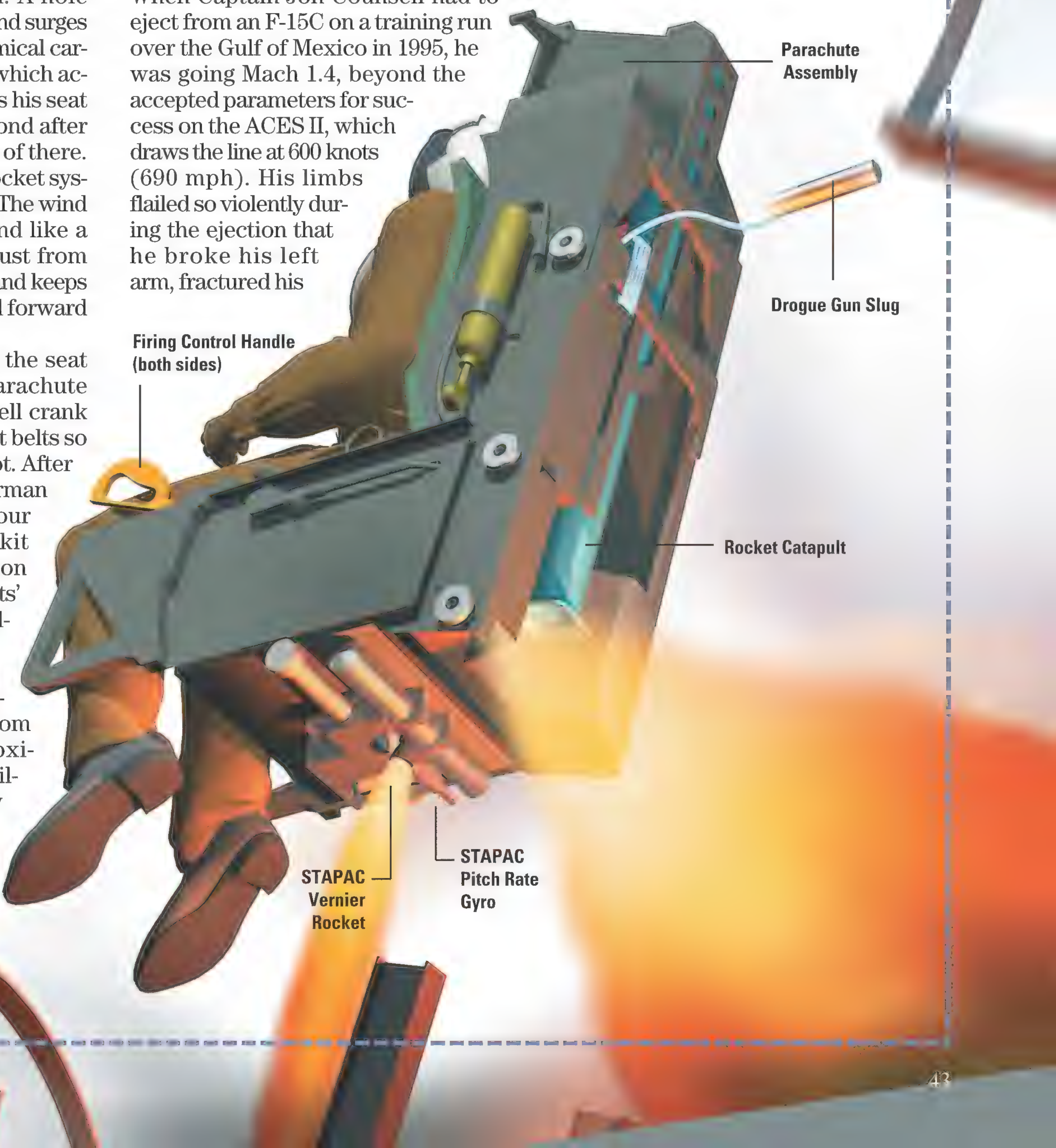
About two seconds after the seat is rocketed upward, the parachute opens, and that triggers a bell crank that pulls the pins on the seat belts so the seat falls clear of the pilot. After all the bang and rush, the airman drifts quietly for three or four seconds. Then a survival kit drops on a 25-foot line. Upon contact with the water, the kits' raft and life vest automatically inflate.

While the success rate for ejections has improved dramatically since the 1940s, from about 50 percent to approximately 90 percent today, flailing limbs can get torn off by 600 mph winds, and ejection delays often shorten descents, and that increases the riskiness of the parachute landings.

Women pilots, who weigh on average 50 pounds less than their male counterparts, are especially at risk because the lighter the object, the faster the toss and the greater the oscillation.

But even in the most extreme conditions, if a pilot doesn't wait too long, the ACES II can usually pull off a save. When Captain Jon Counsell had to eject from an F-15C on a training run over the Gulf of Mexico in 1995, he was going Mach 1.4, beyond the accepted parameters for success on the ACES II, which draws the line at 600 knots (690 mph). His limbs flailed so violently during the ejection that he broke his left arm, fractured his left leg in five places and dislocated both knees. Doctors thought he'd never walk again, but seven years later he's back in the cockpit. In an exchange with the Navy, he now flies F/A-18s.

"I had to make one decision—to pull the handle," he says. "After that, 13 automatic functions had to work perfectly for me to live, and they did."



RUSSELL MUNSON

my first time

Aerospace celebrities talk about the flights that changed their lives.

Interviews by Phil Scott

EDWARDS AFB

SCOTT CROSSFIELD

TEST PILOT, X-1, X-15, AND OTHER LEGENDARY AIRCRAFT

It was 1927, and the pilot was Carl Lienesch. He worked for my father at the Union Oil Company. Lienesch, he flew around to the various oil fields in use. Used Alexander Eaglerocks and Travel Airs. And my first flight was in an Eaglerock, and Lienesch took me for a ride out of Monrovia, California. That was before Lindbergh flew the Atlantic.

I was in the front seat and I enjoyed it. But I fell asleep. I was only six or seven years old.

REEVE LINDBERGH

AUTHOR; DAUGHTER OF CHARLES LINDBERGH

All I can remember is a flight with my father when we had a forced landing. I think I was maybe seven. It was out of Danbury [Connecticut], and what he rented—I know this was true because I asked [Lindbergh biographer] Scott Berg—was an Aeronca with a tandem cockpit. He didn't own a plane. He would take us up and my brother and sister would take off and land; all I could do was pull back on the stick. He would shout stuff like "Lean in the curve," and he had all these phrases like "An airplane is like a bobsled."

The choke malfunctioned and I was quite excited. I asked, "Are we going to crash?" He said, "No, but put your head down between you knees." I found it quite boring because I couldn't see much.

We landed in a cow pasture. There were no cows but lots of rocks. They had to take the plane apart to get it out.

COURTESY GENERAL JOHN R. DAILEY

GEN. JOHN R. DAILEY

(USMC, RET.) DIRECTOR, NATIONAL AIR AND SPACE MUSEUM

My first flight was when I jumped in the front seat of a T-34. I was 23 years old. It was everything I hoped it was going to be.

My dad was a marine aviator but I had never flown, never been in the cockpit of an airplane. I felt completely prepared for it, having gotten through ground school and bailout school. They hook you up with an instructor and away you go. I was impressed that they pressed you as fast as you could take it. Every hop you were learning something new. They'd give you a solo or two to practice on your own, and then give you a check ride. It may sound naive, but I couldn't believe I was getting paid to be there.

> **You got into this thing and you started that engine and it torqued, and I thought to myself: *I wonder if I'm in the right place.***

I was in the Marines, and it took me about 14 months to get my wings. Would have been July of '58. It was in the Mentor, actually a Beech Bonanza with a tandem cockpit. We did spins on the very first hop. And aerobatics. We transitioned to the T-28, which had the R-1820 radial. You got into this thing and you started that engine and it torqued, and I thought to myself: *I wonder if I'm in the right place.* It's quite an airplane. Everybody I know thought the same thing.

EILEEN COLLINS

SPACE SHUTTLE COMMANDER (MISSION STS-93)

> **I got the window seat and spent most of the time trying to calm my mother down.**

I was 19 years old. My mother and myself, we flew from Elmira, New York, to change planes in Chicago and landed in Denver or Colorado Springs. We were taking a little vacation. My brother was a freshman at the Air Force Academy—a fourth classman, first year—and my mother and I went out for Parents' Weekend or Labor Day Weekend, and we flew out on a Thursday or Friday and flew back the following Monday. I got the window seat and spent most of the time trying to calm my mother down. She was drinking coffee and shaking— she was nervous the entire flight. I've got to give her credit: She isn't as afraid as she used to be. So anyway, I enjoyed looking out the window. For the first time I saw what the ground looked like from the air. That was about the time I started thinking about flying myself.

NASA

The first time I flew myself would have been '77, in a Cessna 150. I went to a local airport, Elmira-Corning Regional Airport. It's beautiful. It's hilly, lot of trees, difficult to navigate in. I never finished my license that summer. We had a lot of fog, and I could only fly in the morning because I worked in a restaurant. I waited till the next summer to finish up my flying lessons.

RICHARD BACH

PILOT AND AUTHOR
(JONATHAN LIVINGSTON SEAGULL)

From about the age of eight I would build little air vehicles and put my eye against the back of the cockpit and say: "This must be what it looks like to fly."

I had my first flight at 15. That flight was in an airplane owned by Paul Marcus. He was my mother's campaign manager; she was running as the first councilwoman of Long Beach, California. He had a Globe Swift and he casually mentioned one day that he flew airplanes. I absolutely started bouncing off the walls. He said, "What's the matter with your boy, Mrs. Bach?" She said, "He loves airplanes." He said, "Let's go out flying," and I latched onto his arm and wouldn't let go. When we walked out to the airport and we walked out the gate—I still feel the sunlight—my eyes were like dinner plates. He taxied out to the runway and talked to the tower and rolled down the runway. The earth started falling away, and I thought, *Oh boy!* I was enraptured and it never quit; it still feels this way.

I always thought about that first flight. Certainly it was the most important moment of my life.

EAA; INSET: JIM KOEPNICK

PAUL POBEREZNY

FOUNDER, EXPERIMENTAL AIRCRAFT ASSOCIATION

Well, my first time was back in 1936, when I taught myself to fly a glider. It was a Waco gilder that one of my high school teachers gave to me when he recognized I wasn't a very good student but my interests lay in building model airplanes and flying model airplanes. So he called me into his office and said I wasn't a good student in ancient history, which is what he taught, but he had a wrecked Waco glider and he offered me money to repair the ribs and buy the dope, and he and I hauled it home. We were a real poor family. My dad had a garage with some wooden planks on the floor. I brought it in the garage and got books on building airplanes and repaired it. My friend had a nice automobile, a coupe, and we took it down to a farmer's field and hooked the glider on the back, and the first thing I knew I was up about a hundred feet. All the farm kids were watching me. And then I pulled the rope to let it go and found out one thing: Keep your nose down. It was so thrilling I couldn't believe it. I can still smell the skid sliding through alfalfa.

> **We took the glider down to a field, and the first thing I knew I was up about a hundred feet. All the farm kids were watching me. Then I pulled the rope to let the glider go.**

RUSSELL MUNSON

Rutan with brother Burt's Long-EZ design

JAMES A. SUGAR

DICK RUTAN

WITH JEANA YEAGER, FLEW THE ONLY UNREFUELED, NONSTOP FLIGHT AROUND THE WORLD

Right after World War II, I was a little tiny kid about eight years old and my mother took me out to a little field near Riverside, California.

I was too small to strap down in the seat. I stood behind the pilot's seat and held onto the seat cushion and the cotton was coming out of it.

I was too small to strap down in the seat. I stood behind the pilot's seat and held onto the seat cushion and the cotton was coming out of it. We bounced out across the grass field and climbed into the sky.

CHUCK YEAGER

SOUND BARRIER BREAKER

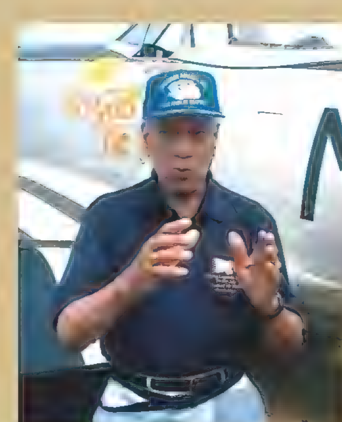
It was in January 1942 and I had never been in any airplane in my life. I was a PFC [private first class], a crew chief on an AT-11 bomber trainer, and I had to change the engines. The engineering officer said, "You want to test the airplane?" I said, "I've never been in the air." He said, "You're really going to enjoy it." Me being raised in West Virginia it was like me looking over a cliff. He flew some touch-and-go's and I got really sick. After puking all over myself, I said, "Yeager, you made a big mistake."

He flew touch-and-go's and I got really sick. I said, "Yeager, you made a big mistake."

LEE ARCHER

WORLD WAR II ACE; TUSKEGEE AIRMAN

I had already been reading *War Aces* and all the old comic books about pilots and the Red Baron and all of that, and that's why I asked my father to get me a ride in the airplane. The first flight was I guess in 1936 or '37, when I was nine or 10 years of age. A guy was flying around, selling rides for a couple of bucks. My father paid for it. It was about 10 or 15 minutes. We took off in a little biplane and that was it. I didn't have a parachute and I didn't have a helmet; I had a hat on and I was sitting in the back seat of I don't know what it was.



RON JENSEN, STARS AND STRIPES

STEVE HINTON

STUNT PILOT; PRESIDENT, PLANES OF FAME MUSEUM

First time I ever left the ground was in an SNJ-5. I was 15 years old. It was at Ontario, California, at the air museum here, Planes of Fame. I went with a museum pilot, Roscoe Diehl. Roscoe was an Air Force fighter pilot and an Air National Guard pilot; he flew Lockheed F-104s.

I was pretty excited about it. I'd worked on airplanes all my life but I had never even left the ground. He let me grab the stick and said: "Try to break the airplane." His point was you can't break it so don't be too ginger with it. It was like 45 minutes. My best recollection is we took off and circled over Ontario and went over Corona, south of Ontario, and cruised around and did some loops and rolls, some aerobatics.

The same airplane—we still have it at the museum here today. I fly it every once in a while.

SEAN D. TUCKER

AIRSHOW SUPERSTAR

I was 12 years old. It was 5:30 in the morning at Hawthorne Airport in California. My father was flying to Fresno and he had an instructor with him. He was learning to fly instruments. He was departing in the dark, taking off and rolling down the runway, and I was scared to death. At 1,000 feet we went into overcast. At 3,000 feet he breaks out of the overcast and the sun was just coming up over the San Gabriel Mountains. And at that moment I knew there was a God.

My father was learning to fly instruments. He was departing in the dark, taking off and rolling down the runway, and I was scared to death.


ERIK HILDEBRANDT; INSET: COURTESY SEAN D. TUCKER

SERGEI SIKORSKY

AEROSPACE EXECUTIVE; SON OF PIONEERING AIRCRAFT DESIGNER IGOR SIKORSKY

I was probably nine or ten years of age. It was in Stratford, Connecticut. I was sort of seated on my father's knee in the copilot's seat of an S-38, a twin-engine amphibian. I remember that we did a brief flight. Oh, it was great. The airplane taxied into the water from the seaplane ramp that still survives—50 years later it's still at the mouth of the Housatonic River. The [Sikorsky] plant is half a mile up-river.

I remember that as the airplane taxied down the ramp into the water, the water kept coming up higher and higher, eventually ending about six to eight inches below the window. But there was absolute calm in the cockpit so I figured everything was under control. Our chief test pilot at that time, he was in the left seat, he opened up the throttles, and for about a few seconds I couldn't see anything out of the windshield because the propeller tips were whipping up such a spray. Suddenly we were on the step and everything cleared off like magic. And maybe two or three brief seconds after that we were airborne. I remember seeing the horizon expanding miraculously.


KEVIN KELLY

LT. COL. MARTHA McSALLY, USAF

FIRST U.S. WOMAN TO FLY FIGHTERS IN COMBAT

I was a kid flying down to Miami and I was airsick and it was miserable. I had my head in a bag the whole trip. If anybody told me I was going to be a fighter pilot I would have laughed. I felt so bad.

The Goodbye Guys

by Beth Dickey

Top of the pyramid: Members of the close out crew (shown on the shuttle launch gantry) can wait years for a spot in the elite corps. Above: Their rolling workshop.

SCOTT ANDREWS (2)

Seeing off the astronauts is one of NASA's most prestigious jobs, and one of the most demanding.

ONE BY ONE, SEVEN FIGURES CLAD IN IDENTICAL ORANGE FLIGHT-SUITS DROP TO ALL FOURS AND CRAWL THROUGH THE CIRCULAR OPENING. A CACOPHONY OF GRUNTS COMES FROM INSIDE THE SMALL CABIN AS THE ASTRONAUT STAND-INS ROLL ONTO THEIR BACKS AND HEAVE THEIR BODIES—EACH WEIGHED DOWN BY MORE THAN 80 POUNDS OF SNUG-FITTING PROTECTIVE GEAR—INTO THINLY PADDED SEATS.

Lying horizontal with black-booted feet in the air, the astronauts quietly wait their turns at strap-in. Three sweaty attendants in white coveralls cinch up seat belts, snap on helmets, and check out radio headsets, seemingly oblivious to the odd, 90-degrees-off-kilter configuration of this space shuttle crew cabin mockup. The nose-up launch position disorients all but the most frequent visitors, but these three are pros, and they've been here before.

No sooner have they finished their work and left the cabin than a muffled shout—"Ready!"—comes from somewhere outside, and all seven astronauts suddenly go limp, pretending to be knocked unconscious by a whiff of toxic air. More attendants throw on gas masks and breathing tanks and pile inside. They yank round green knobs on the spacesuits to activate the victims' oxygen supplies, then begin unstrapping them and dragging them out—head first, with feet still up. The evacuation drill takes six minutes, almost double the record of three and a half, and a minute longer than the goal. They'll have to do better next time.

NASA calls it a Mode 2 Egress Simulation. "We call it astronaut appreciation training," says spacecraft mechanic Rene Arriens. Rescuing astronauts is a high-energy feat that Arriens is sure he couldn't do twice in rapid succession in a real emergency. But he practices it as many as eight times daily when he and other members of NASA's close out crew—perhaps the most elite corps of space shuttle workers, apart from the astronauts and mission controllers—gather for annual, week-long training sessions in Houston and at the Kennedy Space Center in Florida.

Unmistakable in coveralls emblazoned with big black digits 1 through 7, close out crew members deliver the last goodbye to astronauts about to rocket off to Earth orbit. "What they do determines whether we're going to get off on time," says astronaut Michael Gernhardt, waiting to board *Atlantis* for a countdown rehearsal on a hot morning last July, a couple of weeks before his mission. Thousands of people get the vehicle itself ready to fly, but only a select few dress the astronauts, help them aboard, seal the orbiter's side hatch, and stand by to break it open again in the event of an emergency. In those last busy hours before launch, it's up to the close out crew to make sure the astronauts have everything they need, and that whatever they don't stays behind.

Their tasks range from the mundane to the heroic. One minute they may be hunting a pencil with a white eraser for a persnickety pilot who doesn't like gray erasers. The next minute, they may save the day (or at least the shuttle launch time) with a quick technical fix. It happened just that way in March of last year, when the odor of overheating wires in *Discovery*'s cockpit three days before the liftoff of mission STS-102 had the launch team stumped. As close out crew chief Rick Welty remembers it, firefighters twice rushed to the launch pad looking for the source of the smell but to no avail. "All the smart money in the Firing Room was on 'No launch—no way.' We were in deep sushi," he recalls. He and Arriens found and verified the problem by literally following their noses, using a couple of soda straws taped together to sniff out a malfunctioning

At the pad, the shuttle is belching hydrogen and oxygen vapors as though it were alive. As often as Rene Arriens and orbiter mechanic Tim Seymour have been here, it's still creepy. "Everything's moving," says Seymour. "Creaking, popping," adds Arriens.

control box behind a circuit breaker panel. The launch went off on time—no small consideration, when a single day's delay on the pad can cost NASA several hundred thousand dollars in wasted fuel, overtime, and other expenses. "What a white-hot troubleshooting experience!" recalls Welty. "It was truly an answer to prayer."

The seven members of the close out crew are among only 21 people routinely allowed access to the space shuttle after its external fuel tank has been filled with volatile liquid hydrogen and oxygen propellants on launch day. The big numbers on their backs make it easier to keep track of everyone. Also, in case of fire or explosion, when the pad would be instantly deluged with water, they'd be easier to identify on closed-circuit TV screens at the launch control center, three miles away.

The numbers are not randomly assigned. Each team includes two spacesuit technicians (3 and 7), three orbiter mechanics (1, 4, and 5), a quality controller (6), and an astronaut (2). NASA uses astronauts exclusively to fill the No. 2 position for the same reason it uses an astronaut as capsule communicator, or capcom, the person at mission control who talks to the orbiting crew. The agency believes astronauts know the language, the equipment, and the environment better than anyone else. "If there weren't an astronaut on the close out crew, there would be a big hole in the whole process of bringing the orbiter to life," says No. 2 Greg "Box" Johnson, who joined the astronaut corps in 1998 but has yet to fly in space. He's among a group of astronauts called "Cape Crusaders," who spend most of their time supporting shuttle flight operations at Kennedy. The proximity to flight hardware ranks No. 2 among the most sought-after jobs in the astronaut office.

The astronaut and quality controller are NASA employees. The rest of the crew works for United Space Alliance, the private company that operates the shuttle. The most experienced mechanic (1) leads the team. Usually shuttle missions have seven astronauts, but when there are only five or six, the

The senior suit technician, who always wears No. 3, greets the STS-104 astronauts at the tower's 195-foot level during a dress rehearsal.

SCOTT ANDREWS

close out crew may grow to eight and include a trainee. The personnel-on-the-pad limit mainly reflects how many people could safely get off the launch tower in a hurry, riding in seven baskets suspended on slide wires that extend 1,200 feet to a bunker on the ground. The baskets are yet another reminder that being a member of the close out crew has its risks as well as its rewards.

On launch day, six or so hours before liftoff, the No. 7 suit tech heads for the astronaut quarters to help the shuttle fliers wriggle into their pressure suits. Meanwhile, the other six members of the team gather a few miles from the pad to wait for a signal from launch control that fueling is finished. When the all-clear comes, they pile into a step van and drive to the pad. On the dashboard is the hood ornament from a Duesenberg luxury automobile, a gift from veteran shuttle astronaut Marsha Ivins, who often wore the "2." The shiny chrome statuette gets a rub for good luck as the journey begins.

The truck is a rolling workshop packed with everything from parachutes to light bulbs to extra insulating tiles for the orbiter. There are eight suitcases full of tools, numbered to correspond with their likelihood of being used. On a normal day, the close out crew will need only the hatch "key" and other items in Boxes 1 and 2. Throw in a few surprises, and they may need the heavy-duty pneumatic drills in Box 3. Box 5, full of chisels and hacksaws, is reserved for a very bad day.

The van arrives at the pad, where the shuttle is belching hydrogen and oxygen vapors as though it were alive. As often as Arriens and orbiter mechanic Tim Seymour have been here, it's still creepy. "Everything's moving," says Seymour. "Creaking, popping," Arriens adds. "Lines are shifting: '*Kkk, kkk, kkk, kkk*,' " says Seymour, trying to imitate the sound. "And if it's windy out, the orbiter's swaying back and forth a little bit," Arriens says. Astronauts are awed by the place on launch day. When they come to the pad for practice sessions, they're often cocky, joking around, says Seymour. "Most of them are—for lack of a better word—like a banty rooster." But when they see and hear the live rocket on launch morning, the mood is likely to be very different. "It is a *very* humbling experience," says Seymour.

The close out crew's first order of business after arriving at the pad is cabin prep and "pre-ingress setup." Chores include draining excess water produced by the orbiter's fuel cells, installing fresh lithium hydroxide canisters that scrub the shuttle's air of carbon dioxide, laying out harnesses and parachutes for the astronauts, and rechecking the position of hundreds of switches in the cockpit.

Everything is done with an eye on the clock. But assuming they arrived at the pad on schedule, about two hours ahead of the astronauts, this is still the most leisurely time of the day for the close out crew. Greg Johnson likes to sit on the flight deck and take it all in, as if the orbiter were a piece of fine art. "There are thousands of little details that you might miss," he says. "Just by sitting back in one of the seats and looking at the big picture, you may see something out of place." There's another benefit to those 15 minutes of solitude: "It gives me a chance to get really excited about my first flight."

The calm is broken about three hours before liftoff. The *whop-whop* of helicopter rotors and the glare of a searchlight signal that the astronaut convoy is approaching the pad. From a vantage point 195 feet up the launch tower, the level where the astronauts will board the vehicle, the Airstream camper carrying the shuttle crew and the police escorts look like Matchbox cars. The close out crew members meet the astronauts at the elevator with quick handshakes or hugs, and the race against time begins. From now on, everything

SCOTT ANDREWS

Working in tight spaces is a requirement of the job. Left: The crew chief (No. 1) stretches inside the orbiter hatch. Below: In Houston, the crew practices emergency evacuation of astronaut stand-ins from an orbiter mockup. The speed record for this drill is three and a half minutes.

DAVID NANCE

happens strictly according to the script, no matter how familiar each person is with the job.

The close out crew does much of its work in the White Room, a small chamber located at the end of the 65-foot access arm that bridges the launch tower and the orbiter. The White Room is joined to the shuttle's circular hatch with a flexible collar or bellows, much like an airport jetway. One by one, the astronauts step to the front of this waiting room and prepare to enter the vehicle through the orbiter's hatch.

Fifty minutes are allotted for strap-in and communications checks. Closing the hatch and pressurizing the cabin should take 30 minutes. If all goes well, about 90 minutes before liftoff, the close out crew will head for a roadblock three miles from the pad. Once in a while a radio glitch or a balky hatch latch forces them to cut it close. "We always like to get off the pad before main engine start," jokes team leader Welty. Arriens points out that some members of the team are cross-trained, so "if the timeline gets really tight, we can basically throw people at a particular task and the job gets done right and safely."

The crew members double as babysitters while the astronauts are waiting to enter the shuttle, when those toward the back of the line have plenty of time to meditate or make inadvertent mischief. Some astronauts opt to use the restroom on the launch tower instead of their government-issue diaper, and need help getting dressed again. "When we're up there working, gender really doesn't matter," Welty offers delicately. "We do whatever we have to do to get the job done."

While waiting to board, astronauts are confined to the 195-foot level. Because of tight timelines and the potential for disaster, corralling the crew must go smoothly. Travis Thompson (No. 1) recalls the time in 1985 when guest astronaut Prince Sultan Al-Saud of Saudi Arabia wandered off to the 215-foot level. "We looked around for him and found him up there on his mat praying [toward] Mecca," says Thompson. "I tried to give him a little time, but I was like, 'Hey buddy, we've got to go.' Now we tell 'em point blank: 'Don't leave!' "

Small even when empty, the shuttle's crew compartment feels like a phone booth when suited astronauts start climbing inside. It can be an emotional as well as a busy time. Arriens recalls one of six-time shuttle veteran Story Musgrave's launches. "He was on the flight deck, and I was in one of the access ports. He reaches out and grabs me and pulls me in and says, 'Thanks.' That meant a lot to me. I said, 'I'll see you when you get back.' "

As the strapped-in astronauts check communications with the launch and mission control centers, two of the orbiter mechanics inspect, close, and pressurize the hatch, while the quality control crew member watches over their shoulders. The slightest nick or ding on a seal around the hatch could cause a show-stopping air leak when the cabin is pressurized for flight. The hatch is locked with a big T-shaped key. To watch the locks engage, the mechanics poke a little mirror, like the ones dentists use, into a hatch pressurization port. Arriens modified another mirror for just this purpose.

If you do this delicate procedure incorrectly, he warns, "you're going to end up taking the hatch apart to get [the key] out." No one wants to become famous, like the close out crew for *Challenger*'s doomed January 1986 flight. The hatch didn't lock properly for the first of two launch attempts. Countdown time ran out while mechanics sawed off the key and drilled out a broken fastener. Although the incident had no bearing on the launch accident the following day, memories of that flight are so painful that close out crew veterans still refuse to talk about it.

Once the cabin is pressurized and checked for leaks, the last couple of insulating thermal tiles are attached to the orbiter near the hatch and the close out crew heads for cover. The job of greeting the astronauts' families in the control center after launch customarily falls to fellow astronaut No. 2. It's considered an honor to do so without a name tag, because the lack of one means the shuttle crew has just carried yours into orbit. Greg Johnson's went to the International Space Station with commander Kent Rominger and the crew of STS-100 in April of last year. Johnson recalls: "As I shook his hand and said a final goodbye, he grabbed my name tag and looked at it, then he stuck it up on the Velcro on the flight deck."

Suit technician Jean Alexander, who's been strapping in astronauts for 20 years, makes last-minute preparations for an emergency evacuation drill.

DAVID NANCE; OPPOSITE: SCOTT ANDREWS

Altogether, about 30 men and women from NASA and United Space Alliance belong to the select close out crew. When not working with astronauts in practice sessions or on actual launch countdowns, they have regular duties either at the Cape or in Houston. All of them are volunteers, and they get no extra hazard pay.

Some, like Jean Alexander, fell into their jobs. At age 56, she was until recently the most senior woman in a group composed mostly of men—or as she likes to put it, "the grandma on the crew." She is confident, no-nonsense, and equally adept with a screwdriver and a sewing machine. "We've been called Space Age valets," Alexander says, "and I guess in some ways, that's basically what we do." She was a secretary in 1980, the year before the shuttle's first launch, when the Johnson Space Center in Houston started offering upward mobility to female clerical workers. As she looked over the abundant postings for administrative assistants and budget analysts, an opening for a spacesuit technician caught her eye. America's first female astronauts were lining up to fly, and Alexander figures that someone thought they'd be more comfortable having another woman suit them up and strap them in.

"You had to be trainable, you had to have some sewing experience, you had to have some mechanical inclination too," she says. "It was on-the-job training from there." More than 20 years later, Alexander was still wearing the No. 3. Recently, though, she stepped down from regular close out crew duty when her job was handed over to United Space Alliance. Alexander trained the contractor employees who replaced her, and will keep her certification for now. Not everyone was happy that NASA's first and only female suit tech also was the agency's last of either gender. "The astronauts," she said before her last mission, STS-110, "feel good having a NASA set of eyes and ears in this area."

Others, like Thompson, deliberately set out to work on the close out crew. He saw his first rocket launch as a military brat in California, and from that day on, he knew the field he wanted to work in. He picked up some machine shop experience at a Union Carbide cryogenics plant, then moved to Florida in 1979 to start punching NASA's time clock. Thompson wanted to work in the "forward shop," where technicians ser-

Mike Gernhardt gets help boarding Atlantis *for a practice countdown. The close out crew "determines whether we're going to get off on time," he says.*

What Goes Up

Partial list of items carried and/or worn by astronauts during a shuttle launch. Some are optional and some, like life support and survival equipment, are mandatory.

Advanced Crew Escape Suit (ACES)
ACES Neck Dam Pull Tabs
Boot Assembly, Lightweight
ACES Glove Assembly
Gloves, Deerskin, Male, Short
Gloves, Deerskin, Male, Long
Gloves, Deerskin, Female
Gloves, Knit
Gloves, Comfort
Teflon Skullcap
Shoulder Comfort Pads, .25" or .5"
Thermal Top
Thermal Bottom, Men's
Thermal Bottom, Women's
Liquid Cooling Pants
Thermal Socks
Name Tag
Pressure Helmet
Very Lightweight Headset
Headset Interface Unit
Communications Pigtail
Hand-held Microphone
Sunglasses with Case
Sunglasses, Crew Preference
Sunglasses, Prescription
Eyeglasses, Prescription
Contact Lens, Case, and Solution
Croakie
Kneeboard, Modified
Kneedesk
Fabric Kneeboard
Checklist Holder
Personal Accommodation Plate
Emesis Bag
Disposable Absorption Garment
Maximum Absorption Garment
Adult Pants
Absorbent Pants
Ziplock Bag
Watch, Aviation Space
Wrist Watch, Personal
G-Shock Digital Watch
Microcassette Recorder
Microcassette Tape, Spare
Calculator, model HP-48SX
Pencil, Silver, w/Lanyard
Drinking Water Container
Carry-on Food
Survival Pack A (Flares, etc.)
Survival Pack B (Radio, etc.)
Knife/Shroud Line Cutter
Lanyard, Self-Doffing
Exposure Mittens
Dosimeter, Crew Passive
Flashlight with Switch Controls
Knife, Swiss Army
Scissors
EMU Wrist Mirror
Handkerchief
Wash Cloth
Headrest
Lumbar Pad
Lower Back Support Cushion
Side Hatch Locking Device
Athletic Headband
Terrycloth Ponytail Holder
Bracelet, Adult I.D.

vice the orbiter's nose section, including the crew module. When he discovered that working there could entitle him to wear a "1," he wanted to do that too. But he was too young and inexperienced. After working and waiting five years, he got to join the close out crew. Eight years later, he finally earned the title of orbiter vehicle close out chief, and now wears No. 1 on launch day. "You don't get anything extra for it and it's a lot of extra work, but guys want to do it," says Thompson. "You know you're doing something important."

Working in the White Room is like working in a fishbowl, and not just because it barely holds six people. "There are cameras everywhere," Thompson complains. The views are broadcast to the public on NASA TV on launch day, and to the launch control center on closed-circuit TV all the time. If they sit down for a break in view of the camera, they risk getting a phone call instructing them to look busy. So when they want down time, they hide in a corner behind the camera.

The attention they earn leads to occasional jealousy from co-workers. Seymour reminds them to think about the worst that could happen: "What they see is a gravy day; everything goes good. When it's a bad day, it's gonna be a real bad day. Would you really want to be there?"

It could start with a small explosion in the payload bay. A pneumatic regulator failing on a pressurized gas tank could launch shrapnel into the forward bulkhead, puncturing the crew module and triggering a nitrogen leak that incapacitates the astronauts in a single breath. Dealing with such an emergency at night would only complicate matters. Launch controllers would cut power to the orbiter immediately. Rescuers would find themselves fumbling in darkness. "Add smoke to the equation and you're going to be doing it by Braille the whole way," says Arriens. "You'd better know how to disconnect a person. If you don't, all the suit pieceparts are going to hang up on everything, and you're never going to get [the astronauts] out." Welty wears a little flashlight on a lanyard around his neck for just such an eventuality. He doubts the fluorescent light sticks tucked into pockets in his own coveralls and the astronauts' pressure suits would provide enough illumination to get the job done.

The closest call so far was the shuttle's first-ever launch pad abort, which occurred in June 1984. One of *Discovery*'s three liquid-fueled engines had already ignited for liftoff when computers aboard the orbiter detected a problem and automatically snuffed the engine. A small hydrogen fire triggered extinguishers on the launch tower, and the water spray drenched the escaping astronauts. "We were all soaking wet and shivering in the cold and thinking, 'This astronaut business is not quite what I thought it was going to be,' " recalls Michael Coats, pilot on the flight. But all were alive, according to Welty, because a watchful close out crew member broke a potentially deadly fall. "When we went up to get them out, we had one astronaut who didn't really want to be in the ship at all," he recalls. The person was "so nervous and jerky that they just jumped out of the hatch and [nearly] went right through the bellows."

The astronauts know that close out crew members stand at the top of a very large pyramid of workers, all of whom deserve their gratitude for preparing the shuttles and the people inside them to fly, year in and year out. But if a problem crops up in those dramatic moments before liftoff, there are only seven people to turn to.

Faking it: Astronaut stand-ins wait outside a mockup during a practice session in Houston.

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A PRICE too HIGH

For three small airports, there's no way back to life as it was before September 11.

by Mark Huber | Photographs by Mark Godfrey

Private pilot Alan Peterson of Metamora, Michigan, was flying his Piper Saratoga to Cambridge, Maryland, on a beautiful Indian summer morning. It was a perfect day for flying: Skies were clear and visibility unlimited over most of the eastern half of the United States. An hour from his destination, an air traffic controller at Washington Approach radioed Peterson: He was to land his aircraft immediately at the nearest available airport. Thousands of commercial and general aviation pilots flying in U.S. airspace had just received the same message. Peterson landed at College Park Airport, a general aviation facility a few miles from Washington, D.C.

Lee Schiek, the airport manager, also got a call from a Federal Aviation Administration air traffic controller. Schiek was told to anticipate unexpected arrivals. In addition to Peterson's Piper, Schiek would have to accommodate 12 aircraft from as far away as Oklahoma and Florida.

The closure of U.S. airspace that had begun on the morning of September 11 continued for an unprecedented 96 hours. Over the subsequent weeks, most of the nation's air traffic system gradually eased back into operation. Airlines resumed flying within days. But private aircraft operating under Visual Flight Rules were grounded for weeks. As a result, aircraft fuel sales, maintenance, and flight instruction, the lifeblood of small airports, stopped. The National Air Transportation Association estimates that in the weeks after September 11, businesses based at the country's 5,000 general aviation airports lost $400 million. By the end of October 2001, most of these operations had returned to some degree of normalcy. However, three small general aviation airports in Maryland—College Park, Washington Executive Airport/Hyde Field, and Potomac Airfield—remained in lockdown for almost six months, because of their proximity to Washington, D.C. All are within 15 miles of the Washington Monument; Executive/Hyde and Potomac are both only five miles from the huge Andrews Air Force Base complex that houses the Presidential fleet. The 360 pilots based at the airports were not allowed to operate from them; their airplanes were grounded indefinitely. After months of waiting to

At Washington Executive Airport/Hyde Field in Clinton, Maryland, airplanes were fitted with prop locks to prevent unauthorized flights. By mid-February, the airport was still closed (below), its resident pilots and businesses scattered.

College Park Airport opened in 1909 as a flying school operated by the Wright brothers; next to the runway is a museum that charts the airport's history. Though the museum remained open after September 11, fewer visitors came, since there were no airplanes to watch take off and land.

learn when they could get back in the air, a group of the pilots heard from U.S. Secret Service special agent George Lusczko, who told them, "Your aircraft or any aircraft can be a delivery system for chemical or biological agents."

It took less than three weeks for the federal government to put together a $15 billion package to compensate the airlines for their September 11-related losses, but as of May 1, tenant businesses at the three small airports had received no federal grants; owners and employees alike had to struggle on their own. Paychecks stopped coming. Personal savings were depleted. Denied access to aircraft, some businesses were forced to move to locations beneath airspace not shackled by new security restrictions. Flight schools suffered the most: Saddled with aircraft and insurance payments and field rents on some of the nation's most expensive real estate, these traditionally low-margin/no-reserve businesses spun into deep trouble within days of the attacks.

"On September 11, I saw our government at its finest hour in terms of its ability to close this airport, get our planes out of the air, and get this facility secured," says Schiek. But after months of straining to navigate among the shifting obstacles set up by a federal government that was itself straining to respond to the crisis, Schiek had another appraisal. "I saw our government at a somewhat different level of responsiveness," he says.

Schiek began his aviation career as the manager of the College Park airport in 1972. He left six years later to pursue his career in airport management and construction. In 2000, he semi-retired and returned to College Park as its manager again. "What amazed me about this place is how little it had changed" in the 22 years since he left, Schiek says. "It's almost like a time warp."

College Park is the world's oldest continuously operating airport. In 1909, the Wright brothers, looking for a place to teach military would-be aviators how to fly an aircraft they had developed for the Army, chose remote College Park as a safer alternative to the field at nearby Fort Myer, Virginia. (The Wrights had been making demonstration flights at the latter, but the commander there felt that the flights were disruptive.) Today an almost religious reverence for powered flight permeates the place. During the nearly six-month shutdown, pilots of law enforcement aircraft were enlisted to make token touchdowns on the single 2,600-foot runway to preserve the airport's "oldest continuously operating" status. The airfield is also home to a restaurant, a museum, and an avionics and aircraft repair shop—College Park Aero Services—owned by Randy Cox. On September 11, Cox was at nearby Baltimore/Washington International Airport, checking the automatic direction finder in a customer's airplane on the general aviation ramp at Signature Flight Support. At

Owner David Wartofsky spent hours lobbying to get his Potomac Airfield reopened. During the shutdown, he was losing $45,000 a month.

about 10 a.m. Signature workers quickly hustled everyone inside the general aviation terminal. A group of professional pilots were clustered around the big-screen television in the lobby. "Their mouths were open and their jaws were hanging down to the floor," Cox recalls.

Cox got in his car and took the Baltimore-Washington Parkway back to College Park. His cell phone didn't work; millions of users dialing at once had collapsed the system. By the time he got to College Park, the air, usually filled with the sounds of aviation, was dead quiet: no noises of jets bound for Reagan Washington National Airport, no Lycoming piston engines clattering on the home runway. Even automobile traffic noise seemed absent. Then the calm was burst: From nearby Andrews Air Force Base, an F-16 fighter took off with a roar.

At Potomac Airfield in Friendly, Maryland, field owner David Wartofsky sat in his office listening to the radio chatter. He heard a controller vectoring a formation of F-16s for an intercept. The airport's Superunicom automated information system was sending out electronic transponder interrogations, and Wartofsky feared the fighters might interpret the transmissions as hostile—"that they were being painted by an unidentified surface radar," he explains. He quickly unplugged it.

Flight instructor Alphonse Musafiri was in a Piper Warrior over the Potomac with a student when American Airlines Flight 77 hit the Pentagon. He had no problem seeing the smoke from the fire. He could smell it in his cockpit, and he feared it might be part of a chemical attack. Shortly after noticing the smoke, he landed at Potomac and swung off the runway just as two police cars moved in to block it.

Nearby Executive/Hyde Field in Clinton, Maryland, also quickly felt the effects of the attacks. Stan Fetter, who operates Fetter Aviation, a Hyde-based business providing Washington, D.C.-area radio stations with airborne traffic reports, flew onto the field a little after 9 a.m. The New York attacks had just occurred, and a group gathered in Fetter's office to watch the events unfold on CNN. Just before 10 a.m. Fetter looked out his window. He could see smoke coming from the direction of the Pentagon. The phone rang. One of his radio station clients wanted him back in the air to overfly the Pentagon attack. His answer was polite but firm: "No."

Stan Fetter (below) owns a Hyde-based business that provides airborne traffic reports for radio stations. After the attacks, he temporarily relocated to Maryland Airport; he obtained an FAA waiver, however, to fly his Cessnas back to Hyde for maintenance (above).

As required by the new federal security system, resident pilots at the three airports underwent fingerprinting and background checks. They also received identification numbers, which they must include when filing flight plans with air traffic control (below).

In the days immediately following September 11, the business owners and employees at these three airports, noting the government's concern for the airlines, expected to be operating normally soon. At College Park, Lee Schiek worked the phones on behalf of his tenants, trying to find out when flying could resume. "No one had an answer," he says. "Phone numbers were changing. People were being transferred overnight and we just couldn't find out anything." Schiek navigated through a shifting maze of government agencies: the National Security Council, the Secret Service, the Federal Bureau of Investigation, the FAA, the Maryland State Police, the Maryland Department of Transportation, and the newly created Office of Homeland Security and Transportation Security Administration. The experience was like being caught in the Abbott and Costello comedy routine "Who's on First?"

Before September 11, Randy Cox had plenty of work on the ramp to keep him busy at College Park. "I figured this was a hiccup and we would be closed for two weeks," says Cox, who started his business 15 years ago at the age of 25. But by the end of the shutdown's first 30 days, Cox knew that patience was no longer economically viable. "I knew I had to sit down and look around at the alternatives," he says.

Ninety percent of his business at College Park was transient traffic, people who based their airplanes elsewhere but brought them to Cox for service. With the airport closed to civilian traffic, that work evaporated and Cox quickly worked through his backlog. Hangar space was available across the Chesapeake Bay, 70 miles away, at the airport in Easton, Maryland. Cox grabbed it and

relocated his business. Not all of his employees were enthusiastic about an 80-minute commute each way, however. Others were concerned about the viability of his business, given that his client base had been cut off overnight. His longtime secretary quit. Others followed. Good avionics employees remain at a premium, and Cox's quickly found work elsewhere.

Cox likes his new Easton facility, but the rent is double what he paid at College Park and business is down 50 percent. He pegs his out-of-pocket losses during the shutdown at $50,000 to $100,000. He still goes back to College Park—to collect his mail. "I'm not sure we'll ever be able to go back there," he says, "but I'd like to be able to support the people on the field who supported me for 15 years while I built my business."

The Potomac airfield has also been suffering, though it is hard to tell at first from its appearance. Situated amid a pleasant tree-lined subdivision of 1940s and '50s brick ranch homes, Potomac is verdant and manicured. The asphalt runway is shiny and smooth, its edges well groomed. Patrons wear designer labels. The pilot supply shop sells cappuccino. The round hangar looks like it was swiped from an elegant 1920s aerodrome. And Potomac's Wartofsky is an atypical small airport operator. He raised his first $1 million in venture capital by the time he was 16. At 17 he learned how to fly and bought an Enstrom F-28 helicopter "to impress girls," he says proudly. He attended Princeton. When not managing the airport, he works on electronic inventions like his Superunicom information system. A toy stuffed moose head adorns his office wall.

After the attacks, Wartofsky advised tenants on the glacial process of reopening the field with postings on the airfield's Web site, replete with witty prose and the theme music from James Bond movies. Like Schiek, he spent hours on the telephone trying to move the process forward. Several aircraft based at Potomac were owned by prominent current and former government officials. Wartofsky knew others from his adventures in capitalism. He called every person in his Rolodex who could help him lobby for reopening. He had powerful incentive to do so: During the shutdown he was losing $45,000 a month.

College Park manager Lee Schiek, being interviewed by a television reporter on the day the airport reopened, made dozens of phone calls to local and federal agencies in an effort to get his pilots back in the air.

Potomac's tenant businesses were also suffering. Wartofsky waived the rents of many during the shutdown, but that was not enough to offset ongoing expenses and lost revenue. Bobbi Boucher, owner of the Plane Doctor, an airframe-and-engine repair shop at Potomac, moved full time to her other shop in Fredericksburg, Virginia. Like Randy Cox at College Park, Boucher relied on transient traffic for the bulk of her clientele. One of the first civilian female aircraft mechanics in the Washington area, Boucher estimates her September 11-related losses at over $50,000. She operates her business by herself with occasional part-time help. "First there was the 'Good Old Boys Network' and now this," she says.

After Wartofsky, Potomac's largest flight school, ATC Flight Training, took the biggest hit on the field. ATC's owner, James Davidson, estimates his shutdown losses at $175,000. "My credit is gone," he says. Davidson applied for an emergency loan from the federal Small Business Administration to save his 12-year-old business, but was turned down because "I wasn't profitable enough before September 11." He adds: "I'd like to see a flight school that is profitable enough" for a loan. Unlike other flight schools at Potomac and Hyde, which rely primarily on part-time instructors with day jobs, Davidson used three full-time instructors. He couldn't pay them for the dura-

Hyde Field opened in 1934 as a training facility for U.S. Army aviators. Despite its proximity to Washington, D.C., the airport retains its rural charm.

tion of the shutdown, but he did establish a fund to which customers contributed to their benefit. After the shutdown, one quit to take a job at the airport in Manassas, Virginia. Davidson's other full-time instructor was Alphonse Musafiri. Musafiri was born in Rwanda. When he was three, his family moved to Brussels, Belgium, where his father was studying to be a doctor. One of Musafiri's earliest childhood memories is wandering away from home at age four. Two military policemen found him stumbling amid the airplanes at the Belgian air force base there. "I think from then on I knew I wanted to be a pilot," he says.

Musafiri came to the United States in 1982. He was 25 and did not speak a word of English. For 13 years he worked a string of odd jobs, including janitor and commercial painter. He married, had a daughter, and bought a house in Maryland. When his marriage ended, he enrolled in the Spartan School of Aeronautics in Tulsa, Oklahoma, to pursue his lifelong dream of becoming a commercial airline pilot. He earned his ratings, graduated in 1998, and returned to Maryland to be close to his daughter. James Davidson hired him, and Musafiri thought he could build flight time fast enough to remain an attractive hire for the airlines. But the longer the airports remained closed, the less time he could give to future ambitions and the more he had to devote to immediate survival. Even in the best of times, primary flight instruction has never been a lucrative profession.

In the middle of October, Davidson got his airplanes out of Potomac during several one-way flushes of stranded aircraft that the FAA had permitted. Police searched airplanes and pilots and examined drivers' licenses before pilots were allowed to depart, and law enforcement agencies and the FAA closely monitored the flights. The first refuge was St. Mary's Airport in southern Maryland's Calvert County. Then Davidson moved his airplanes to Maryland Airport in Pomonkey, Maryland. But Washington-area roadway traffic can be brutal, and few students chose to brave the long drives and turn a one-hour flying lesson into a half-day ordeal. Musafiri's flight hours dropped from eight hours a day to one a month. Because he had to pay child support, he went back to picking up odd jobs. The Salvation Army covered his rent.

Musafiri is not optimistic about achieving his ultimate ambition. The airline industry is not hiring many pilots, his flight hours have been cut, and at 44, he is much older than most airline pilot hires. "I'm flying but my dream is gone," he says.

Executive/Hyde Field is close to Potomac, but in appearance Hyde is a world away. Hyde's dominant decor is rust. The runway is sloped and cracked, its edges littered with mud and gravel slopped from trucks transiting the adjacent pit. Some of the concrete block and Quonset T-hangars look like they would collapse in a strong breeze. Herbert Jones, 78, owns a flying school at Hyde called the Cloud Club. In the days following September 11, Jones saw his retirement dreams turn into a nightmare. A pilot since 1946 and an active member of the Tuskegee Airmen, Jones worked a day job in the assignment branch of the U.S. Patent Office until he retired 20 years ago. He's been in the flight training business for more than 15 years. Since September 11, Jones has struggled with the expenses of rents and insurance, but he has not had to lay anyone off. When Hyde was shut down, Jones thought to himself: *This won't last very long*. Now, struggling with losses after almost six months, he contemplates getting out of the business. "But I think I'll hang in there a little longer," he says.

Retired U.S. Air Force chief master sergeant Larry Kelley, 71, is not a pilot. But he opened Beacon Flying Service, another flight school at Hyde, because "I just like airplanes and aviation guys are good guys," he says. Kelley's last assignment for the Air Force was superintendent of quality assurance for the 89th Wing of the Military Airlift Command, including the Presidential fleet. During his military career, Kelley flew as a flight mechanic on everything from B-25s to C-47s. Between 1969 and 1972 he flew aboard the ponderous C-47s on navaid checking flights over Vietnam, exercises that were magnets for Viet Cong ground fire. But nothing prepared him for the shot he took on September 11. Kelley lost $10,000 a month during the shutdown and he estimates that his retired or part-time instructors lost about $8,000 each for the duration. "I figured maybe we'd be shut down for a couple of days," he says. "Boy, did I learn a lesson."

Milton Gilley operates a maintenance shop at Hyde. September 11 forced Gilley to lay off employees, among them his son-in-law, Mark Gifford. As for money, Gilley estimates that during the shutdown he lost "38,000 by the books." Business is "way down," he says, but stoically adds, "I'm going to keep to it for the moment. I just as soon go bankrupt myself than have the government bankrupt me."

Stan Fetter's traffic reporting business was shut down until November 30, when he resumed operations flying from Maryland Airport under a special FAA waiver. He estimates that his business has lost more than $300,000. Fetter used his retirement savings and the proceeds from

After her home base closed, Bobbi Boucher moved her airframe-and-engine repair business full time to her other shop in Fredericksburg, Virginia.

an SBA loan to cover shutdown-related losses. Resuming flying has reduced but not eliminated his red ink. "This has never been a business in which you are going to get rich," he says. "My margins aren't that great."

Fetter is visibly angry about the time it took for the government to devise a plan to reopen his home airport and the effect the delay had on the aviation communities there. "Not to minimize the prices that were paid by those directly impacted on September 11, but there's a batch of people out here who paid too high a price for what came afterward," he says. "And there was really no reason for it."

Lloyd Coleman, a Beacon flight instructor based at Hyde, thinks the ultimate price may yet to be exacted: "I don't think business will get back to the way it was before 9/11," he says.

At 8:35 a.m. on February 23, pilot Leon Jackler, an attorney with the Federal Communications Commission, landed his 1975 Grumman Yankee at College Park, the first resident civilian pilot to land there since September 11. After being shut down for nearly six months, College Park, Potomac, and Hyde had lost at least a collective $1.3 million—and much of their clientele. As of May 2002, only 35 of College Park's previously based 87 aircraft had returned.

When College Park reopened on February 23, local pilots took pleasure in the sight of airplanes once again flying over the little field.

At Potomac Airfield in Friendly, Maryland, the drone of engines was replaced by the sound of silence.

Is Fatigue Fatal? | Stephan Wilkinson

An accident blamed on the catch-all "pilot error" could have a single preventable cause.

The rules that specify how long an airline pilot can be on duty before resting and how long that rest must be fill little more than a page in the Federal Aviation Regulations.The Air Line Pilots Association document "Guide to Flight Time Limitations and Rest Requirements," detailing how those rules work, is over 19 single-spaced pages long and bears the warning "This booklet cannot answer all questions concerning the application of the rules…."

Until terrorist attacks were made against the United States on September 11, the confused and inadequate state of airline duty-time regulations was thought by some to be the single greatest threat to U.S. airline safety. In fact, just one day earlier, on September 10, the major airline pilots union issued a press release headlined "ALPA Irate Over Court Stay of Pilot Fatigue Rule." Several pilot unions had charged that the rules were poorly written and unclear, were being fiddled with by the airlines to make pilots work more hours, and were out of date. But the Federal Aviation Administration had convinced a U.S. Court of Appeals that the rules, FAR Part 121.147, were adequate, and although they needed some fine-tuning, there was no need for haste.

A bit of haste might have averted a June 1999 American Airlines accident in Little Rock, Arkansas, when a flight crew, obviously fatigued at the end of an overlong but legal duty day, did a lousy job of landing their MD-82 during a gusty thunderstorm. The captain and 10 passengers were killed when the airplane went off the end of the runway. Yet the FAA continues to argue that "the vast majority of pilots are receiving the amount of rest required by the FAA's rule." (Hard to imagine the Feds defending other regulations this way, saying that "the vast majority" of turbine engines are well built or that "the vast majority" of pilots have valid medical certificates.)

Current FAA rules on airline pilot hours limit flight time to eight hours (this can be exceeded "due to circumstances beyond the control of the carrier," such as inclement weather) and duty time to 16 hours. Thus, if a pilot takes off on an eight-hour flight from Point A to Point B at 0900 and arrives at the airport at 0700 to check the weather and go through his preflight routine, his total duty time is 10 hours. If, however, the pilot shows up at 0700 for the same flight but then waits an additional three hours for a mechanical problem to be resolved before takeoff, the flying time to Point B is the same but his duty time has now ballooned to a long but still legal 13 hours. The Air Line Pilots Association would like to limit duty time to 12 hours, while the Air Transport Association, which represents airline management, would like duty time to be extended past 16 hours in the event of problems with weather, aircraft maintenance, and air traffic control.

Airline pilots may indeed be receiving the rest required by the rules, but the FAA hasn't the faintest idea whether pilots are in fact rested.

For most of the country's workers, the clock starts when they arrive at work and stops when they leave. Should pilots operate any differently? As one former accident investigator put it, "Awake is awake. Why should there be any difference between time spent briefing, checking weather, preflighting, awaiting equipment, and sitting out delays, and time spent flying?"

Airline pilots may indeed be receiving the rest required by the rules, but the FAA hasn't the faintest idea whether pilots are in fact rested. There is virtually no hard data on the effectiveness of pilot rest periods. Which suggests that rather than saying "Airliners aren't falling out of the sky with pilots asleep at the switch, so everything must be okay," the FAA should liberalize the regulations to allow flight crews more sleep and then put researchers to work studying rest patterns. If it's demonstrated that pilots are getting more rest than they need, then and only then should the regs be ratcheted back up.

A pilot's rest might come at an odd, hard-to-sleep time—two in the afternoon until 11 p.m., say—and the nine hours of "rest" might well include two hours of round-trip travel, check-in/out between airport and hotel, and time to eat a meal. Pilots also sometimes contribute to their own fatigue. A surprising number commute long distances to work, stretching duty days to extreme lengths. Former NTSB accident investigator Rudy Kapustin recalls working a Pan Am crash in San Jose, Costa Rica: "The pilot originated the flight in Florida, but his home was somewhere in the Northwest," he recalls. "So he had commuted a six-hour flight, and gotten up two hours before that, before he'd even started his working

entary

day. He got all screwed up on the approach and hit short of the runway. He was completely out of it."

Some pilots also bid for a month's worth of trips in grueling blocks, so they can minimize trips to their base and get all their flying done in closely scheduled chunks. That routine doesn't help their sleep cycles. And senior captains often bid for the long international routes. "I spent six months doing nothing but flying from the West Coast to the Far East," says one middle-aged captain. "The average legs were 12 or 13 hours long, and it's so boring that your alertness is slowly eroded away. By the time you actually shoot the approach, you're not very sharp despite the fact that you've had crew rest. By the time you reach Japan, you're wide awake yet you can feel yourself fatigued. You try to go to bed, you can't sleep, and by the time you're flying back eastbound, your body is trying to tip over."

Fatigue is an insidious thing. If it weren't, people wouldn't fall asleep while driving. "Those guys who crashed at Little Rock should have gotten off in Dallas [at the end of the previous leg] and walked away from the airplane," opines a 767 captain. "But they chose to press on, probably feeling they were okay. That's the thing about being tired—you really don't feel it yet, and your decision-making capability is diminished."

The NTSB listed crew fatigue as a major factor in the Little Rock crash, but how many other accidents have resulted at least in part from fatigue? Flaps mis-set, navaids mistaken, procedures confused, emergencies mishandled, approaches botched, ATC clearances misheard.... Were these all simply the result of "pilot error," or did pilot fatigue play a part? We'll never know, for sleep-deprivation accidents rarely leave clues, and if pilots survive, how many are likely to admit: "I just destroyed a $40 million airplane, killed dozens of people, ended my career, and opened myself up to enormous liability because I violated the FARs and I flew when I was too tired"?

DAVID POVILAITIS

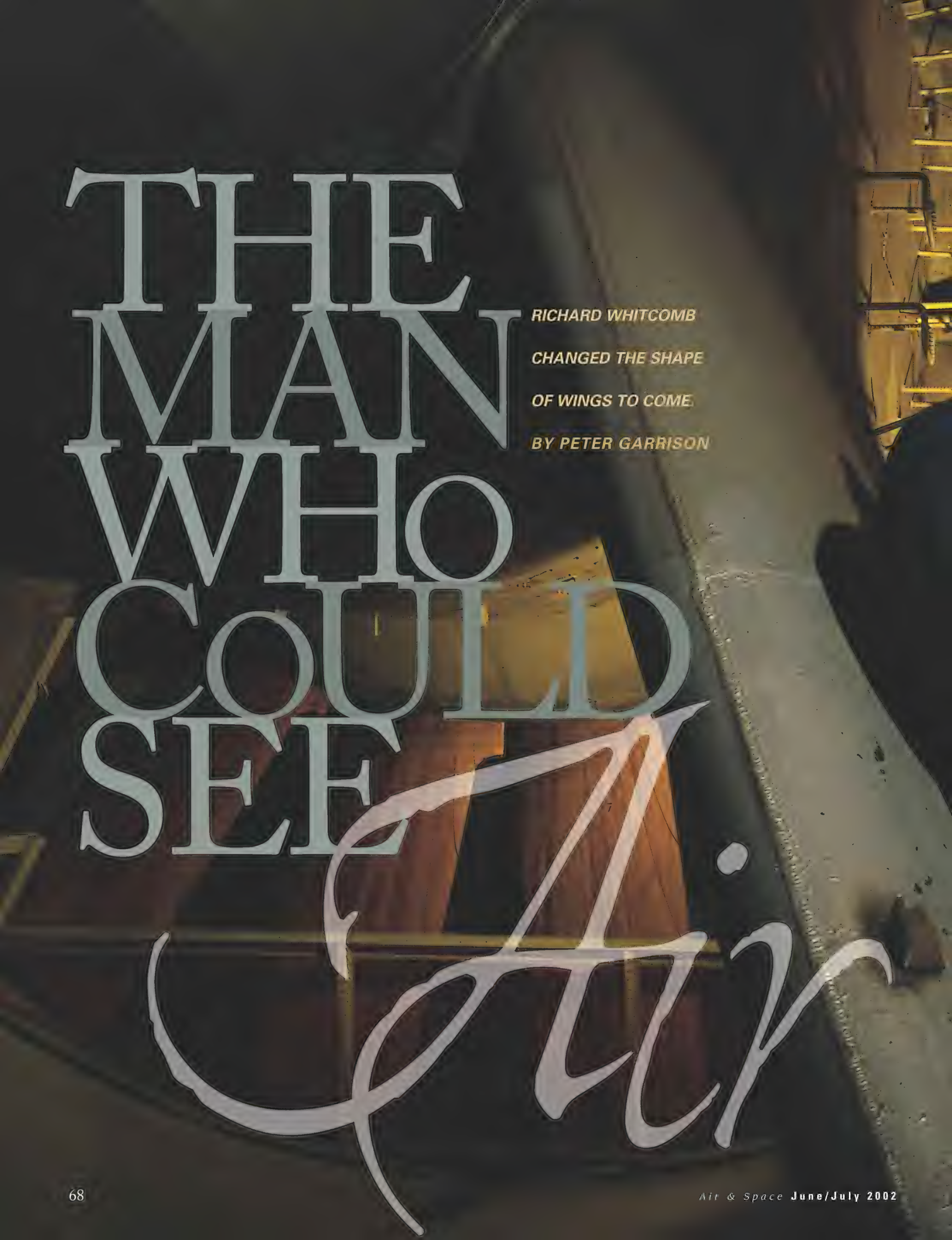
If a pilot flies when he is fatigued, he is in violation of FAR 91.13, which states: "No person may operate an aircraft in a careless or reckless manner so as to endanger the life or property of another." The FAA considers that this one rule will cover everything from sleepy pilots to those who have sprained an ankle playing softball, overdosed on their meds, drunk too much, suffered an emotional upheaval, or gone through anything else that would make them unsafe in the cockpit.

Some airlines say that their policy permits pilots to abandon a flight due to fatigue with a guarantee of no recriminations. Some pilots say, "Yeah, right. Try it and see what happens." Yet others maintain that the option is there at least in part so that those who apportion blame after an accident can say, "It was her fault; she should have taken herself out of the cockpit if she was that tired."

"On my last month at American, I ran into one of those creeping-delay situations," recalls retired American Airlines captain Robert Besco, who holds a Ph.D. in industrial psychology and has written extensively about aviation safety. "They wanted us to take one more leg and I said no. The chief pilot got all over my case about it, the copilot was still on probation and wouldn't stick his neck out and agree that we were dead tired, so we went ahead and flew from Oakland back to Dallas. We didn't crash, so it must have been safe." Unfortunately, the burden of adhering to the duty-time regulations falls largely upon pilots, who are asked to make go/no-go decisions just at the time when their judgment is likely to be compromised.

The Airline Transport Association avers that because pilot fatigue has not been proven to be a problem, more restrictive duty-time regulations would add unnecessary costs to airline operations. In an era of $1.98 airport security, $300 Blue Light Special round trips to Europe, cattle-car coach travel, and a near-total abandonment of customer service in what is, after all, simply a service industry, perhaps it's time to pay some costs once thought unnecessary.

Stephan Wilkinson rides plenty of airliners as a monthly columnist for *Popular Science*, a frequent contributor to Delta Air Lines' magazine, *Sky*, and the automotive editor of *Condé Nast Traveler*.



THE MAN WHO COULD SEE *Air*

RICHARD WHITCOMB CHANGED THE SHAPE OF WINGS TO COME.

BY PETER GARRISON

Great ideas are mysterious things. Where do they come from? Do they float down from above, launched like paper gliders by a playful muse? Or do they percolate up out of inner darkness, eventually to erupt into consciousness? Are they born fully formed, or do we construct them out of bits and pieces? Or is an idea not a construction at all but a kind of dissolution, a solvent that breaks apart things we believed to be related and allows them to recombine differently?

In 1951, Richard Travis Whitcomb, a slender, sandy-haired man, sits, feet up on his desk, at the Langley Research Center of the National Advisory Committee for Aeronautics in Hampton, Virginia. He wears a dark coat and a tie, and, as always, he is smoking a cigarette. He's thinking. Suddenly, something else is there, a presence, an annunciating angel: the Idea. It's not worked up to step by step like the answer to a long-division problem, but just there all at once. "I suddenly realized that the disturbances and shock waves are simply a function of the longitudinal variation of the cross-sectional area."

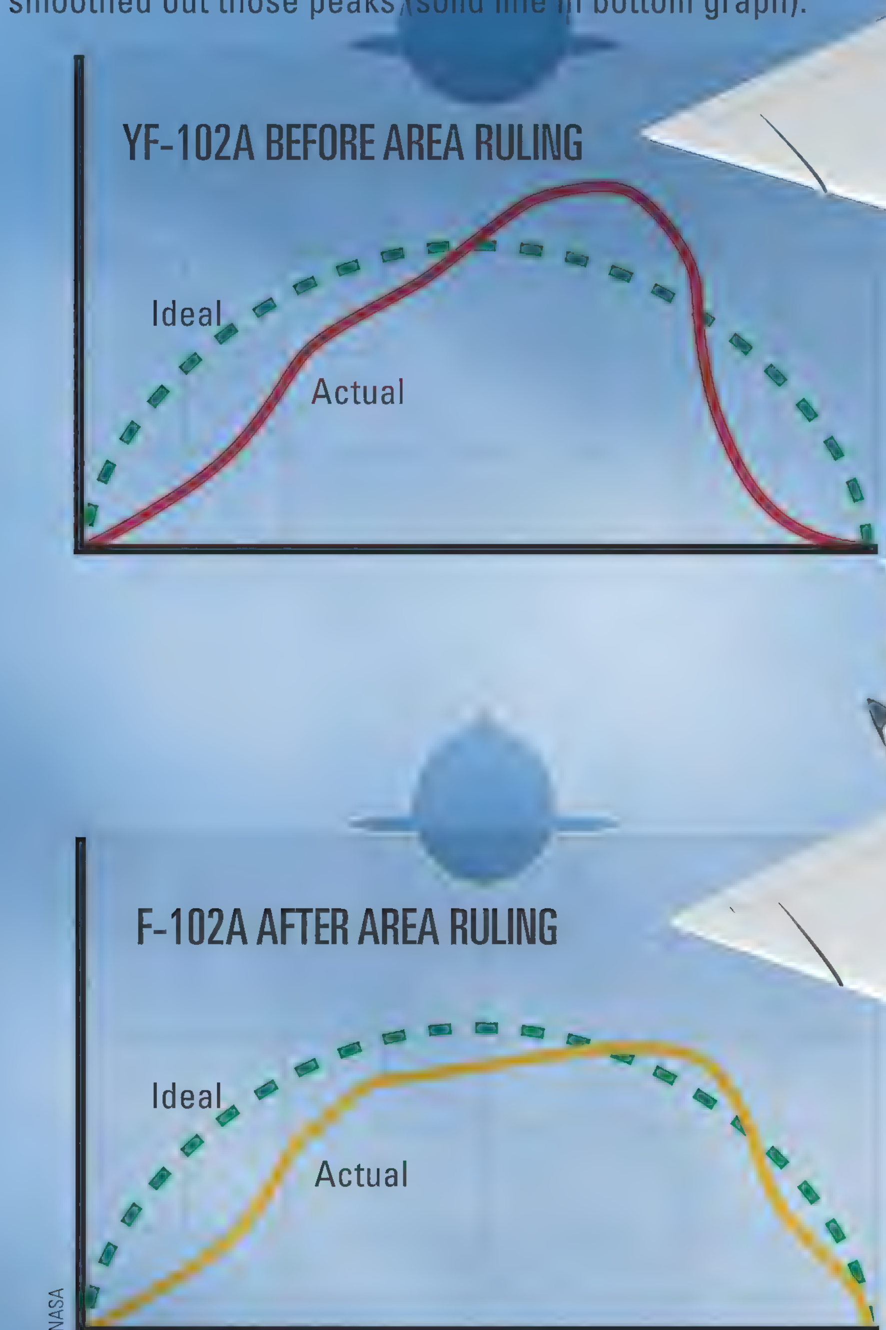
Whitcomb's insight was that at speeds near that of sound, the disturbances in the air produced by a complex object like a streamlined body with protruding wings would be largely equivalent to those produced by a simple streamlined body without wings, but with, in their place, a sort of midriff bulge with a frontal area the same as that of the wings. The idea was so simple that it seemed incredible that no one had had it before.

What Whitcomb's discovery solved was nothing less than the problem of the famous "sound barrier"—the steep increase in drag and the onset of control problems that beset airplanes as they neared

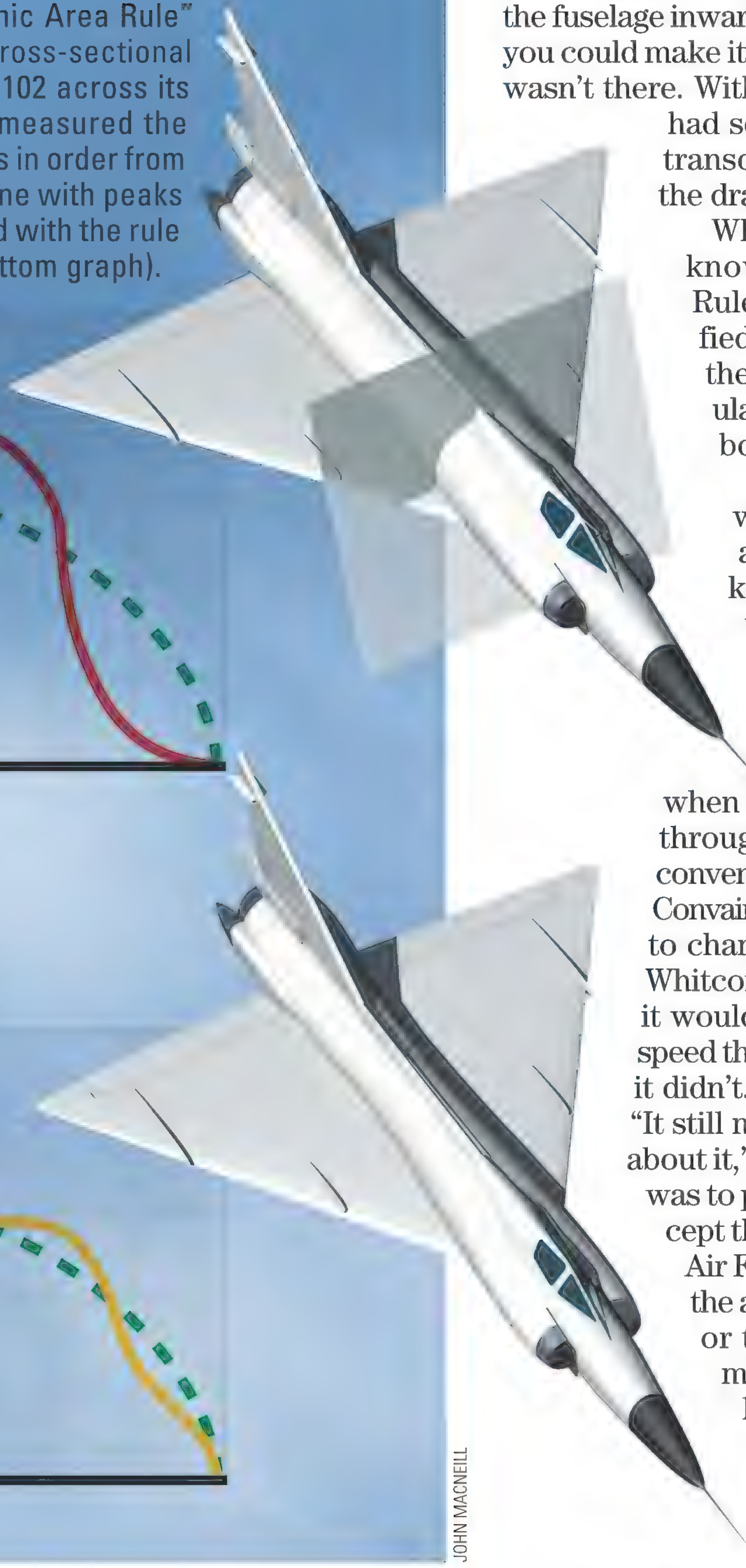
TIM WRIGHT

One Airplane, Sliced Thin, To Go

The word "area" in the term "Transonic Area Rule" refers to the linear variation of the cross-sectional area of the airplane. If you cut an F-102 across its long axis in a thousand thin slices, then measured the area of each slice and graphed the numbers in order from nose to tail, the result would be a curved line with peaks (solid line in top graph). What Whitcomb did with the rule smoothed out those peaks (solid line in bottom graph).



NASA



JOHN MACNEILL

the speed of sound, and that, in 1951, was the principal preoccupation of the U.S. and Russian air forces and the airplane manufacturers who supplied them.

To define the problem in terms of replacing wings with a midriff bulge, as Whitcomb did in the brief secret report in which the NACA revealed the discovery to industry, was a little coy, because nobody was really interested in finding novel ways to produce the same amount of drag. What mattered was what the insight implied. It wasn't until the last couple of pages of the epoch-making paper that Whitcomb pulled the rabbit out of his hat: If you sucked the fuselage inward in the vicinity of the wings, you could make it look to the air as if the wing wasn't there. With a single stroke Whitcomb had severed the Gordian knot of transonic aerodynamics and cut the drag rise by half.

Whitcomb's idea came to be known as the Transonic Area Rule, but when it was declassified and made the front page of the *New York Times*, the popular press dubbed it the "Coke-bottle fuselage."

At a time when jet engines were less powerful than they are today, the idea was the key to some airplanes' ability to achieve supersonic speeds. One was the Convair F-102, a delta-wing interceptor, the prototype of which was nearing completion when Whitcomb made his breakthrough. Already committed to a conventional cigar-shaped fuselage, Convair's management was unwilling to change the design even though Whitcomb's analysis indicated that it wouldn't achieve the supersonic speed the Air Force required. Indeed, it didn't. Management's first ploy—"It still makes me mad when I think about it," Whitcomb bristles today—was to pressure the Air Force to accept the airplane as it was. But the Air Force wouldn't have it; either the airplane had to go supersonic or the contract would be terminated. Finally Convair relented and built a new, area-ruled fuselage. The Coke bottle F-102A accelerated through Mach 1 while still climbing.

It happened that the internal layout of the F-102, and also that of its beautiful successor, the F-106 Delta Dagger, permitted deep area-ruling of the fuselage. Other designs were more tightly packaged and couldn't be squeezed. In the case of the Republic F-105, rather than narrowing the fuselage in the vicinity of the wing, Whitcomb proposed fattening it before and after the wing—the goal being, if the total cross-section could not be reduced, at least to make the longitudinal variation of area more continuous. "The [proposed] fuselage looked

like a bowling pin," Whitcomb recalls, and Alexander Kartveli, chief designer at Republic, "wasn't happy. He liked his airplanes to look sleek." But when he saw the wind tunnel results, Whitcomb says, Kartveli decided the fuselage didn't look so bad after all.

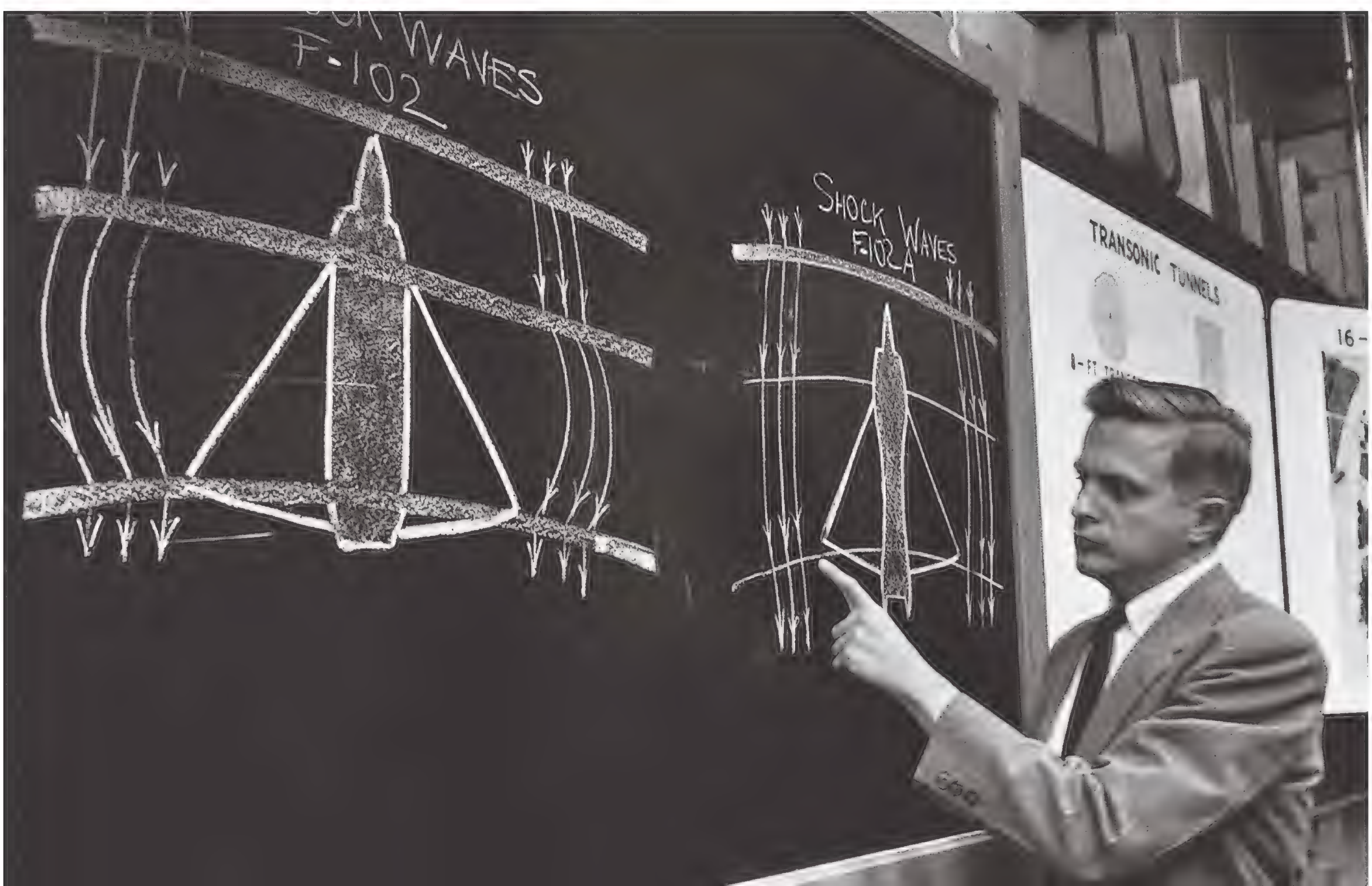
"I think that what looks good usually is good," Whitcomb says, though the example of Kartveli illustrates the circularity of the argument: One's sense of what looks good is, after all, conditioned by the looks of other things that have already been demonstrated to be good. But in Whitcomb's case that rule had a deeper meaning, because Whitcomb, unlike his colleagues at Langley and most other workers in the abstruse field of transonic aerodynamics, was in a sense an artistic rather than a theoretical or mathematical thinker. He did not interpret numerically the condition of the flow he was investigating; he felt it. "He was different from anyone else. He had a physical feel for fluid dynamics—and he was very, very good at it," says Larry Loftin, Whitcomb's longtime boss at Langley. Anthony Jameson, a mathematical aerodynamicist who worked with him in the 1970s, agrees. "Whitcomb," he says, "had different thought patterns."

The difference served him well. The Transonic Area Rule had, in fact, been implicit in earlier work by other researchers, but—perhaps because they were concerned only with the purely mathematical aspects of the problem—they had somehow failed to see its importance for practical aircraft design. Because Whitcomb saw the problem and its solution in physical terms, he was the one who reaped credit for the discovery of the rule.

Whitcomb was born in Illinois in 1921. His father, who had been a balloon pilot in World War I, was a mechanical engineer specializing in the dynamics of rotating machinery. When Richard was in his early teens the family moved to Worcester, Massachusetts, where his father went to work for Norton, a manufacturer of industrial abrasives and grinding equipment. There was little camaraderie between father and son, Whitcomb recalls, but the son had his own impulse toward aeronautics. He built model airplanes and flew them in competitions, always driven by the idea that "there must be a better way to do this"—by reducing drag or increasing propulsive efficiency. He learned a valuable lesson about aeronautical engineering from rubber bands: You could get more work out of a band that was stretched straight than one that was wound up, but the mechanical apparatus to convert straight stretch into propeller spin was so complicated and heavy that it nullified the advantage. It was an important thing for a novice aeronautical engineer to grasp: Airplane design was a matter of sometimes painful tradeoffs.

Whitcomb's idea came to be known as the Transonic Area Rule, but when it was declassified and made the front page of the New York Times, *the popular press dubbed it the "Coke-bottle fuselage."*

Whitcomb, featured in Life *magazine in 1956, "had an ego," a co-worker says, "but he deserved to. He knew that he was good."*



GEORGE SKADDING, TIMEPIX

NASA LANGLEY (2)

Even with careful area ruling, Whitcomb's supersonic transport design would never break the design-stage barrier: Supersonic flight inevitably incurred drag penalties.

Whitcomb received the National Aeronautic Association's 1954 Collier Trophy for "the greatest achievement in aviation in America" for the Transonic Area Rule. He had become a bright star in a normally obscure firmament.

When he started at Worcester Polytechnic Institute he stopped building models—"I put aside childish things"—but gained experience in experimental wind tunnel work. After graduation in 1943, he presented himself at the Langley center, looking for work. Building up its staff as fast as it could for the war, the NACA snapped him up.

The NACA's principal contribution to aeronautics during World War II was the testing and improvement of existing designs—basically, aerodynamic cleanup. It was a conservative policy for which the agency would be criticized when the war was over and it was discovered how far the Axis had pulled ahead in original research. America caught up by collecting and importing Germans and Italians, and Whitcomb was carried forward in a torrent of aerodynamic research alongside the likes of the brilliant Adolf Busemann, who had proposed the use of swept wings for transonic flight as far back as 1935, and Antonio Ferri, the leading Italian authority on high-speed aerodynamics.

Wind tunnel tests proved that Whitcomb's winglets reduced the drag of the entire aircraft by as much as eight percent and reduced vortex drag up to 20 percent.

Problems of transonic flow moved to the foreground of aerodynamics research after the war and came to be the ones that would occupy Whitcomb throughout his professional life. The term "transonic" had been coined to describe the range of speeds in which the flow over the airplane was "mixed"—partly subsonic and partly supersonic (see "Home on the Transonic Range," opposite). In some cases, sonic-velocity flow appeared on airplanes at speeds as low as 300 mph, but for most practical purposes the transonic region began around 500 mph—a speed that propeller airplanes could barely attain but at which jets came into their own.

Chuck Yeager nudged the bullet-shaped, thin-wing Bell X-1 uneventfully past the so-called sound barrier in 1947. The X-1 was conventionally configured, but it was a hot rod—a very small, light airplane whose powerful rocket engine consumed fuel at a terrific rate. New fighters were bigger, heavier, and, because of the state of jet engine design at the time, less powerful, and the speed of sound was still a barrier to them. It was in the context of those early efforts to build a genuinely supersonic jet fighter that Whitcomb made the breakthrough of the Transonic Area Rule, and received the National Aeronautic Association's 1954 Collier Trophy for "the greatest achievement in aviation in America." He had become a bright star in a normally obscure firmament. There was little jealousy or resentment among his colleagues, however, in part because Whitcomb, amiable and always generous with his time, was well liked. "He had an ego," says Gerry South Jr., former head of the theoretical aerodynamics branch at Langley, "but he deserved to. He knew that he was good."

In 1957, the space race began in earnest with the Russian launch of Sputnik. Responding to widespread alarm over the United States' having apparently lagged behind its enemy, Congress created NASA in 1958. The NACA disappeared into the larger agency, and space loomed so large in NASA's agenda that the future of aerodynamic research was in doubt.

Langley chief John Stack defended his shrunken aerodynamics directorate by fo-

cusing its research efforts on the development of a supersonic transport, then seen as the natural successor to the jet airliners that had entered service only a few years earlier. Whitcomb, who in 1958 had become head of the transonic aerodynamics branch, developed his own SST design. It was beautiful, he says, but, like all SST proposals, impractical because the supersonic regime could not avoid drag penalties. Around 1962 he abandoned it and cast about for another project. It came to him in the form of the supercritical wing.

There was clearly a need for airfoils suitable for transonic flight—ones that experienced a gradual drag rise rather than a steep one once supersonic flow had appeared. The problem was that there was no approach to designing them comparable to the mathematical methods then available for subsonic airfoils. The transonic situation was many times more complex.

Whitcomb's first clue to a solution came in the form of unexpected wind tunnel results for an airfoil intended for use on a vertical-takeoff fighter. A section of the airfoil had a flap, with air passages, or slots, between the flap's leading edge and the wing, and Whitcomb found that the flap was capable of delaying the appearance of the shock wave that was responsible for the transonic drag rise. After studying the slotted section for some time, he concluded that it could not work well when fabricated with reasonable precision. Abandoning the slot, he turned his newly enhanced intuitive grasp of shock wave mechanics to the creation of a shockless single-element airfoil. His tools were the ones that had served him in the past: the wind tunnel and his creative mind.

The tunnels with which Whitcomb worked had eight-foot test sections lined with thick steel plates and slotted to prevent "choking" at transonic speeds. The roar of their fans, powered by 16,000-horsepower electric motors, could be heard and felt through the building day and night. The first—the "old" HST, or high-speed tunnel—was open to the humid Virginia atmosphere, and in the summer, models became invisible in the test section because of the fog that formed as the flow speed built up and the air pressure inside consequently dropped. The data-gathering equipment was in the chamber surrounding, and open to, the test section, so the researchers worked armed with ear muffs to prevent deafness and oxygen masks to avoid hypoxia. The "new" eight-foot tunnel, which entered service in 1953 after Whitcomb's area rule work was largely done, had a closed circuit. It recirculated the same dry, fog-free atmosphere, it could be pressurized to increase the density of the working air, and its data gathering space was insulated from the test section.

Characteristically, Whitcomb's approach to airfoil design was sculptural, intuitive. Beginning with a conventional wing of two-foot chord (distance from leading to trailing edge)

Home on the Transonic Range

The speed of air passing over a body increases over bulges and decreases into cavities, and the air pressure varies in inverse relation to the speed. This is the Bernoulli phenomenon, to which wings owe their ability to produce lift.

When an airplane is moving very fast, the flow over some parts of it, in particular the upper surfaces of the wings, accelerates to supersonic speed, even though the airplane itself is flying below the speed of sound. The airplane speed at which local supersonic flow first appears is called the "critical speed" or "critical Mach number." For wings with conventional subsonic airfoils, it is typically around Mach .75, or about 500 mph. The range between the critical speed and Mach 1.0, the speed of sound, is called the "transonic range." Problems confronted the first airplanes exploring those speeds. Patches of supersonic flow generated shock waves that could disrupt the subsonic flows in their wake, causing massive turbulence, loss of lift, and an increase in drag to two or three times the subsonic value.

JOHN MACNEILL

Immediately after World War II, as airplane speeds were entering the transonic range, the nature of transonic flow was not well understood. Tests were conducted with weighted models dropped from airplanes at high altitude, carried on the noses of rockets, or mounted above a bump in the floor of a wind tunnel. But progress was slow until Ray Wright, a researcher at the National Advisory Committee for Aeronautics center at Langley, Virginia, working, like Whitcomb, with filler and file, discovered how to tailor slots in the wind tunnel's walls so as to yield reliable results up to and beyond the speed of sound.

When transonic phenomena could be studied under controlled conditions in a wind tunnel, they yielded their secrets to Whitcomb and others. New ways were found to reduce or eliminate shock waves. Whitcomb coined the term "supercritical" to describe airfoils designed so that the drag rise occurs well past the critical Mach number. Supercritical wings are now used on all new airliners and business jets, enabling some of them to cruise economically at speeds as high as Mach .92.

Before the first tests of the supercritical wing on full-scale aircraft, Whitcomb himself, ever the sculptor, climbed out on the wing of the F-8 with a hammer to irritably reshape some protruding sheet metal.

equipped with instruments to measure pressures along the chord, he added bulk here with plastic auto body putty and removed it there with a file and sandpaper, looking for a pressure distribution that would delay and weaken the shock that arose at the point where the upper-surface flow decelerated from supersonic to subsonic speed. It was not a simple job; pressures and velocities could not be changed at one place without producing unwanted changes everywhere else. It's unlikely that anyone but Whitcomb would have thought to undertake it. But he did, working two shifts a day, sleeping at times on a makeshift cot, obsessively completing run after run in the transonic tunnel.

By the late 1960s Whitcomb had pioneered a new class of airfoils. Their shapes were counterintuitive—the leading edge was blunt and thick, in contrast to the knife-like sections usually associated with supersonic flight; the upper surface was so gently curved as to appear almost flat; the lower surface bulged so deeply that the airfoil seemed to be flying upside down; and its trailing edge hooked downward with a cusp so marked that it almost resembled a deflected flap.

As with the Transonic Area Rule, Whitcomb was not alone in his line of investigation. A British researcher, H.H. Pearcey, had designed a class of "peaky" airfoils that achieved a moderate delay in the drag rise and were used on the first generation of jet transports. Other researchers had noted, with puzzlement, bizarre evidence that conventionally cambered airfoils seemed to have lower drag at transonic speeds when operating upside down—that is, with the same relatively flat top and bulging bottom that would become the hallmarks of Whitcomb's section. As with the Transonic Area Rule, however, it was Whitcomb's intuitive approach to the physical problem, through sculptural experimentation and wind tunnel verification, that succeeded where paper and pencil had failed.

NASA DRYDEN

A Vought F-8 Crusader outfitted with a supercritical wing verified wind tunnel test results and won Whitcomb another aviation trophy.

Nevertheless, Whitcomb agreed with his bosses at Langley, who, while acknowledging the importance of his accomplishment, observed that not every airplane manufacturer in need of an airfoil could be expected to adopt his manual procedure for designing it. There had to be an analytical method—that is, one that enabled transonic sections to be arrived at mathematically. NASA let a substantial contract to the Courant Institute at New York University, where mathematician Paul Garabedian and aerodynamicist Anthony Jameson, in consultation with Whitcomb (one of whose strengths, Jameson says, was a readiness to look at other people's ideas), eventually developed a practical computational method for designing what Whitcomb termed "supercritical" airfoils—those that were most efficient in the transonic range.

Full-scale test aircraft—in 1971 a Vought F-8 Crusader, and in 1973 a General Dynamics F-111—were equipped by NASA with supercritical wings and flight-tested at the NASA Flight Research Center in California (renamed the Dryden center in 1976). Before the first tests, Whitcomb himself, ever the sculptor, climbed out onto the wing of the F-8 with a hammer to irritably reshape some protruding sheet metal. The experimental findings supported the wind tunnel measurements, and the term "supercritical" became part of every aeronautical engineer's vocabulary. The supercritical wing won rapid acceptance by industry. NASA conferred upon Whitcomb a $25,000 prize, and he received the 1974 Wright Brothers Memorial Trophy from the National Aeronautic Association.

Unexpectedly, Whitcomb's supercritical airfoil produced a spinoff for general aviation. Its thick, blunt leading edge allowed it to generate an unusually large amount of lift before stalling, and Whitcomb published a low-speed airfoil, which he called the GA(W)-1—for General Aviation (Whitcomb)—which has been used in several small airplanes.

Whitcomb next turned his attention to the problem of a complete supercritical aircraft, and, three decades before Boeing announced its Sonic Cruiser, he designed a "near-sonic transport" theoretically capable of operating economically at 98 percent of the speed of sound. As with the supercritical wing, Whitcomb developed his design in the wind tunnel with body putty and a file, subtly adjusting its marked area-ruling in order to muffle secondary shocks arising from the intersec-

tion of body and wing. But Whitcomb's near-sonic transport configuration was never to be adopted for a full-scale airplane. There were various reasons. One was the rising cost of fuel in the early 1970s, which led airlines to demand not faster aircraft but more economical ones. But this was the era of the Concorde as well—hardly an economical design—and a more mundane reason may also have played a role: Since its fuselage varied continuously in width, the Whitcomb configuration did not accommodate a regular arrangement of seats and aisles. Or maybe it was just a simple case of "not invented here."

It was in response to the airlines' post-oil-embargo demand for increased efficiency that Whitcomb produced his third innovation, the one perhaps best known today: the winglet. That some kind of barrier at the tip can improve a wing's performance had been known for decades, but Whitcomb was apparently the first to realize that such a barrier would be most efficient if it took the form of a supplementary vertical wing. Although experimental winglets reduced fuel consumption by five percent or more, designers were skeptical of the idea, and it was slow to take hold. Today, however, many transport aircraft and business jets have winglets. So do a number of lighter airplanes for which they are not really appropriate and to which they have been added for looks alone. (See "How Things Work," Aug./Sept. 2001.)

In 1980, Whitcomb, 59, suddenly—and, to many who knew him, surprisingly—retired. His reasons were several. One was mental and emotional exhaustion from unsuccessfully grappling with a project outside his field of transonic aerodynamics. It was a scheme seemingly from the border of science fiction that at once lured and resisted him: to harvest energy from the environment in ways that conventional physics forbade but, he thought, quantum physics just might allow. Another more prosaic reason was a disagreement with management. Headstrong, independent, and confident in his own insights, he no longer cared to work in NASA's increasingly bureaucratic and compartmentalized organization, and on projects that he believed—the aftermath has borne him out—to have no future. He continued for years afterward to consult with industry. "Basically, I told them what they were doing wrong," he says. His clients got their money's worth; Whitcomb "could explain things better than anyone I ever saw," says former colleague Gerry South. But the work eventually dwindled. "By now," Whitcomb says, "what I know is old hat."


NASA LANGLEY

The "strangulation" of airflow around a model in a wind tunnel was solved by cutting slots in the walls of the eight-foot tunnel at Langley. Transonic research then took off.

At 81, Richard Whitcomb is one of aviation's grand old men. A brisk, trim, white-haired figure, he takes long walks in Hampton, where he has lived since 1943. He watches his diet; his principal activity these days, he says, is "staying alive." He likes 19th century classical music, and pictures and sculptures whose forms seem to him to embody deep principles of energy and motion. He lives alone. He never married, but for 25 years kept company with a NASA mathematician, Barbara Durling; she died last year. Several of his more prestigious awards are on display in his small apartment, but he has received, and still receives, too many for his shelves and walls to handle. "I'm at the age," he ruefully jokes, "where they start to give you those 'lifetime achievement awards.' "

His apartment building is beside a narrow estuary of the Chesapeake Bay. Across the water is the wind tunnel in which he spent his professional life. The tunnel was both a home and a friend to him. Without it, he says, he could never have become what everyone today agrees he is: one of the greatest aeronautical scientists of the 20th century.

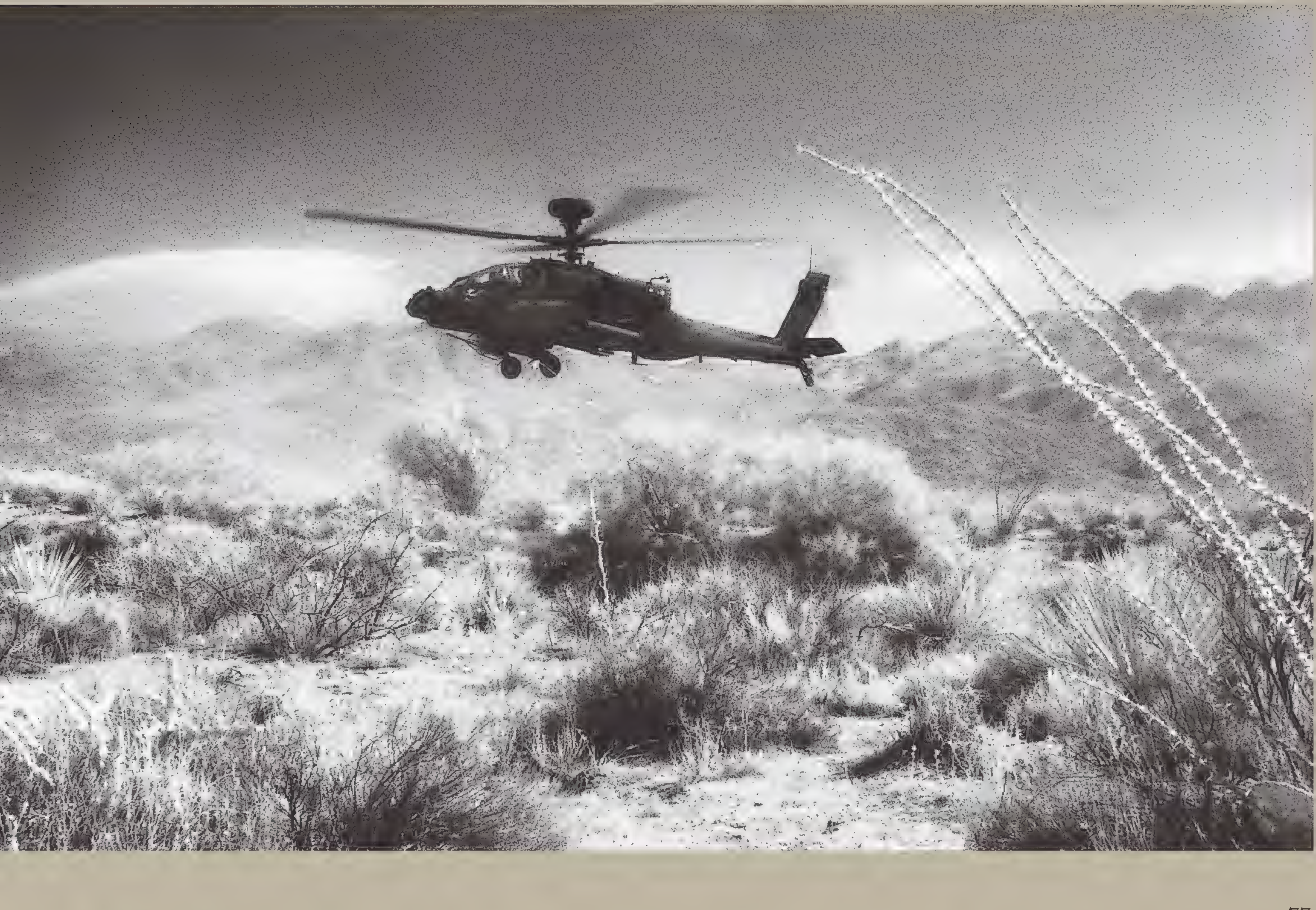
SIGHTINGS

The assignment: Photograph an Apache AH-64D Longbow attack helicopter in the desert outside Phoenix, Arizona. The challenge: Make your images different from those created by the 60 other photographers out there with you.

That was the task awaiting attendees of the second annual International Symposium of Aviation Photographers, held last February in Mesa. Taking a break from the conference, they arrived at the site around noon and set about selecting film types, camera angles, and lenses to make distinctive photographs of the Apache, which flew out from a Boeing factory nearby. Renee Ekman, who lives in Misawa, Japan, came up with one of the tightest shots, which effectively captures the menace of the Apache head-on (right). San Diego-based photographer Tom Twomey managed to find an unusual vantage (opposite, top): "I chose an unobstructed position away from the main crowd to get a different perspective, but in a place to try to maximize the mid-day lighting conditions. I used a zoom lens to get tight shots of the maneuvering helicopter, paying particular attention to the background and using a slow shutter speed to get the turning-blade effect."

Gary Edwards went for a completely different approach: infrared (opposite, bottom). "As it turned out, the characteristically stark infrared rendition of vegetation added a great deal to the central theme of this image—that this helicopter is at home right down in the weeds," Edwards says. "There is a technical relevance here as well: Modern combat aircraft are very intentionally treated to reduce infrared signature. Even with a film stock that records only reflected infrared energy [as opposed to radiant infrared], one can see from its dark image that the Apache designers have done a good job here."

Mike Goettings then took on every photographer's nightmare assignment: the dreaded group shot, this one of the Apache and 60 of its closest friends (bottom right).



Kosmic Karma

Portraits of space pioneers Sergei Korolev (left) and Konstantin Tsiolkovsky hang in a classroom at the Scientific Research Institute of Chemical Machine-Building.

Kosmos: A Portrait of the Russian Space Age

by Adam Bartos. Princeton Architectural Press, 2001. 176 pp., $40.00 (hardbound).

This astonishing book, with hundreds of superb photographs of all aspects of the Russian space program and an insightful 10-page essay by Svetlana Boym, a professor of Slavic languages and Russian history and culture at Harvard University, is a delight to both the eye and the mind. It is neither a history nor a technical analysis, but it provides an immersion in a world familiar yet not fully known to Western space workers and enthusiasts.

Adam Bartos, a New York-based photographer, visited Russia several times in 1997 and 1998. To prepare for the trip, he carefully consulted with U.S. space history experts about what to look for and what he might expect to see. But his greatest assets were his skills and sensibilities as a photographer, which yielded fascinating compositions and unexpected views.

To be sure, the hardware is all there: the desert launch complex at Baikonur, space vehicles in various stages of assembly, training devices, and factory scenes. But the workplaces and homes of program leaders and ordinary workers are also included, revealing a uniquely Russian character. As I went through the book, I experienced my own visual adventures: A scene that at first seemed empty or bland revealed, under further inspection, what had caught the photographer's eye. I realized that, after so many of my own visits to these locations, I hadn't really seen much at all—until I saw these photographs.

Bartos has created touching portraits of many leading figures of the Soviet program, most long retired. His photograph of Vasiliy Mishin, director of the Soviet space program at the time it lost the moon race, is the finest shot I've ever seen of him. It's especially valuable because Mishin died late last year. His portrait is only one in a gallery of giants.

The scenes in the book capture the essence of Russia's space facilities so vividly that the viewer's other senses are activated; you can almost feel a wood desk, hear the rustle of old notes or the roar of a launching, and smell the odors of a workshop.

Although there is an attempt to provide background information on all of the photographs, their sequence is so disjointed and the photographs so vivid that you can't really make sense of the whole unless you have a fairly good overview of the Soviet program before starting. For those who don't, the book's images may motivate them to seek deeper knowledge. For those who already have such knowledge, the book will add insights to their understanding.

—James Oberg (www.jamesoberg.com) *is a space engineer, consultant, and author. His most recent book is* Star-Crossed Orbits: Inside the US/Russian Space Alliance.

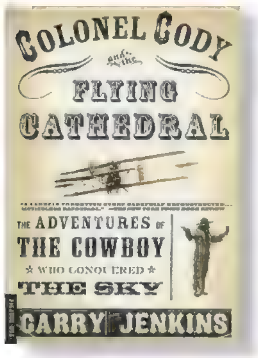
Colonel Cody and the Flying Cathedral: The Adventures of the Cowboy Who Conquered the Sky

by Garry Jenkins. Picador USA, 2001. 288 pp., $13.00 (paperback).

The American cowboy-showman Samuel F. Cody made the first "powered and sustained" flight in Great Britain, covering 1,390 feet on October 16, 1908. He's almost totally forgotten today, but as this welcome biography reminds us, Cody was once

the most popular (and one of the earliest) of the "daring young men in their flying machines." When he crashed and died in August 1913 at age 46, 100,000 people lined rural roads outside London to witness his funeral procession.

Cody's real life is entertaining enough (and the photos in this book are wonderful), but he always spiced it up. Jenkins, searching through the "myth and reality, hokum and half-truth," reveals that Cody hadn't, as claimed, grown up in a remote Texas ranch house besieged by Indians. Rather, he was born Franklin Samuel Cowdery in Davenport, Iowa. He adopted the name "Cody" hoping to be associated with the more famous Buffalo Bill.



Cody led such an interesting life that airplanes don't even show up for the first half of the book. He worked with sharpshooter Annie Oakley, raced chariots in Rome, appeared on stage in melodramas like *The Klondyke Nugget*, and crossed the English Channel one night in a boat towed by a 15-foot kite.

His fascination with kites eventually led him to produce gigantic man-lifters he thought could be used for military purposes. From there he produced Britain's first airship, the *Nulli Secundus*, which flew in 1907, and the British Army Aeroplane No. 1, which he flew the next year.

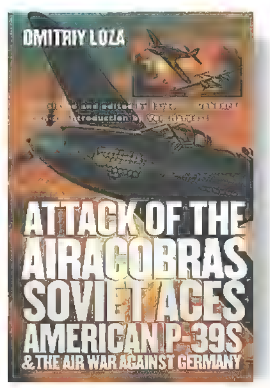
In a 1904 sales brochure for one of his giant kites, Cody wrote: "I hope at no very distant date to play an important part of the complete conquest of the air." Jenkins' fascinating biography reminds us that the flying cowboy indeed accomplished just that.

—Longtime Air & Space *contributor Richard Sassaman writes from Bar Harbor, Maine.*

Attack of the Airacobras: Soviet Aces, American P-39s, and the Air War Against Germany

by Dmitriy Loza (translated and edited by James F. Gebhardt). University of Kansas Press, 2002. 369 pp., $34.95 (hardbound).

Snubbed by the British and panned by most U.S. pilots, the Bell P-39 was nevertheless a favorite of famed test pilot Chuck Yeager, who did his combat training in the Airacobra. "The Thirty-Nine was a fun airplane to fly," he recalled, and it "performed beautifully at low altitudes." And this was just where the Soviets needed it—they didn't need a high-flying interceptor or a long-range bomber escort, but a frontline patroller, breaking through escorting Me 109s and Fw 190s and shooting down low-flying Stukas and Ju 88s before they could attack the troops below.



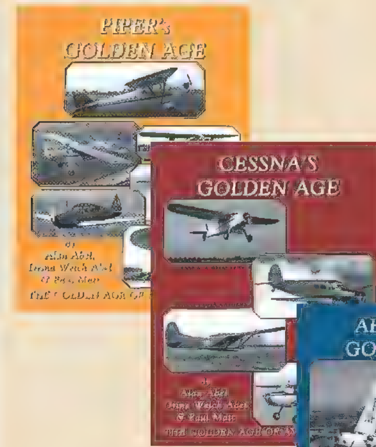
Almost 5,000 Airacobras produced under the Lend-Lease Act saw action against the Germans along the entire Eastern Front, and *Attack of the Airacobras* follows the Soviet 216th Fighter Division and its P-39s from March 1943 in the skies over the Kuban watershed, where the Soviet Union mounted its first significant challenge to the Luftwaffe, to the final Berlin campaign in May 1945.

A hero of the Soviet Union and a former Sherman tank battalion commander, Loza consulted many sources and conducted extensive interviews with former P-39 pilot Mikhail Petrov. Editor James Gebhardt translated Loza's manuscript, adding insightful chapters on logistics, maintenance, and other essential support functions. The result is a valuable volume, and the latest entry in the Modern War Studies series.

From the beginning, Loza argues, ace Aleksandr Pokryshkin employed the P-39 as a catalyst for modernizing Soviet air tactics, perhaps foreshadowing John Boyd's energy-maneuverability theory, which was so vital to victory in aerial combat in the war. For Pokryshkin, control of the vertical (rather than horizontal) plane was crucial, and his new "bookshelf" formations enabled pilots to gain the speed needed for head-on "fist" attacks through the front of German bomber formations and in slashing "eagle strikes" from above.

Furthermore, the arrival of the P-39, with its IFF (identification friend or foe) installation and radio, provided the Soviets with capabilities unavailable in their earlier aircraft, greatly increasing air-to-air and air-to-ground tactical flexibility. But Loza's narrative disproves the myth of the P-39 as tank buster, for only during the final drive on Berlin was the Airacobra used as a close-air-support

GEN-AV HISTORY



Piper's Golden Age/ Cessna's Golden Age/Aeronca's Golden Age

by Alan Abel, Drina Welch Abel, and Paul Matt. Wind Canyon Books, 2002. $22.95 to $24.95 (paperback).

Wind Canyon Books continues its Golden Age of Aviation series, published to commemorate next year's centennial of powered flight, with three new titles covering three aircraft manufacturers: their formation and growth, technical details on all of their important aircraft, and insights into the impact the companies had on general aviation in the United States, particularly during times of war and economic boom or bust. Archival photographs and technical drawings abound.

ENGINE ARCANA

R-2800: Pratt & Whitney's Dependable Masterpiece

by Graham White. SAE International, 2002. 718 pp., $49.00 (hardbound).

The Pratt & Whitney R-2800 18-cylinder radial engine—widely considered to be the best piston engine ever built—powered many fighter and transport aircraft in World War II and passenger airplanes after the war, and to this day it continues to move cargo aircraft around the world. No detail about the R-2800 can possibly exist that isn't included in this enormous tome, which contains enough charts, color graphics, technical descriptions, developmental histories, and information on each of the airplanes the R-2800 powered to keep engine owners and historical enthusiasts very well informed.

fighter-bomber, strafing enemy supply trains and troop concentrations.

But Loza largely neglects to place the 216th Fighter Division (redesignated with the honorific "9th Guards Fighter Division") in the larger context of the war as a whole: There is no mention of the Soviets' earlier use of P-39s along the whole Eastern Front and during the Battle of Kursk. Also missing are German observations on the tactical and strategic impact of the P-39. The maps are largely inadequate, listing almost none of the locations over which some of the 216th's fiercest air battles raged, such as the more than 20 major air engagements protecting the Soviet bridgehead along the Sivash River in the Crimea.

The book also neglects to provide much basic information about the Airacobra itself—there's not even a drawing showing the P-39's unusual engine and 37-mm cannon mounting. Nor does it recount the two main reasons that the P-39's performance above 15,000 feet was compromised: The Soviets replaced the prototype's turbocharger with a single-stage gear-driven supercharger, and by adding guns, ammunition, and armor plating, they increased the aircraft's weight by an incredible 25 percent.

On the other hand, superb anecdotes abound: desperate ramming of P-39s into their adversaries, for example, and pilots being fired upon by countrymen in Yak-1s, who in early 1943 did not recognize the P-39 as a Soviet newcomer.

There are occasional glitches: The book's paper is uncoated, so the photos often reproduced poorly. The photographs also include aircraft irrelevant to the text, and there are none of the P-39's adversaries. One Soviet pilot is described as having "pitched his fighter to the side," and the notes section states that a "spin" involves "rotation of the aircraft around its longitudinal axis," instead of the vertical axis.

Finally, Loza's narrative concludes abruptly with a statement that at the end of the war, all ammunition was accounted for. The author provides no summary of the 9th Guards Fighter Division's overall effectiveness, no tallies of German aircraft downed by the P-39, and no lists of Airacobras lost in the process. Such puzzling analytical, technical, and cartographic problems unfortunately prevent this book from achieving its full potential.

—Lee Gaillard is a Philadelphia-based writer specializing in military issues and technology.

Flight Simulator 2002: The Sky's the Limit

Microsoft, 2001. CD-ROM for PCs, $49.95.

From crude adventures such as flying under wire-frame bridges or passing between blocky mountains, *Flight Simulator* has come a long way in the past 20 years. But it hasn't always been a smooth flight.

The dilemma, of course, for civilian flight simulations has been to make the world outside the virtual cockpit appealing and the experience inside it true to life. The sheer magnitude of re-creating the experience of flying on a personal computer has resulted in flight simulations generally being one of two types: great-flying simulations or great-looking simulations. Microsoft's best-selling franchise has always tried to do both, and as a result has been criticized, rightly, for creating a product that falls short of either.

Enter *Flight Simulator 2002.* (First scheduled for release in October, Flight Simulator 2002 was held back a month so the developers could remove the World Trade Center towers from the New York skyline.) Unlike previous versions of the simulation, in which the designers seemed to tweak the program or simply tack on a few new features, *Flight Simulator 2002* is an almost wholesale overhaul of the product. Employing improved technology used to develop the Combat Flight Simulator series, the developers have created a simulation that is as stunning to look at as it is satisfying to fly. Ground textures and contours taken from satellite imagery create a window view matching what you'd expect to see in real life. In addition to the program's 21,000 airstrips and some 60 detailed cityscapes around the world, an auto-generated scenery system fills in the surrounding landscape with objects appropriate to the area. Where minor cities used to be represented by blotchy patches and a few nondescript buildings, now factories, highways, shopping centers, and parks pop up. You may not be able to fly over your house in this simulation, but you'd swear you could. The auto-generated

scenery makes the program easier to look at and adds much-needed depth and contrast to low-level flight, particularly on approach to an airport.

But the program goes beyond that. Major airports are carefully and beautifully detailed, right down to the loading docks sticking from the terminals. Fly over the coast and waves break on the shore, jets produce contrails, and tires spew smoke on landing. Fly on New Year's Eve in some cities and you'll be entertained with a fireworks display. The Las Vegas Strip is lined with more than a dozen superbly detailed casinos.


Screen shot from inside a Cessna 172.

In addition to the standard stable of airplanes—Learjet, Cessna 182, Boeing 737 and 777, Schweizer sailplane, and Bell JetRanger, among others—*Flight Simulator 2002* has added a Boeing 747-400, a Cessna 172, and, most fun of all, a Cessna Caravan equipped with floats. The airplanes too have been given an overhaul, rendered down to the last rivet, with some even showing signs of wear and tear.


A Cessna Caravan's simulated landing.

Another major addition to *Flight Simulator 2002* is the interactive air traffic control system. From flight plan clearances to taxi instructions and en-route traffic advisories, recorded voices of up to 10 controllers can monitor your flight from startup to shutdown, scolding you should you fail to follow instructions. The controllers are also busy controlling other aircraft. Unlike the dynamic aircraft included in previous versions (basically just moving elements with scenery), these artificially intelligent airplanes have minds of their own, competing for the attention of air traffic control and keeping you on the lookout as you approach an airport. Taxi for takeoff at Chicago's O'Hare and you might find yourself stuck behind a line of airliners also waiting to take off.

As did the previous version of the program, *Flight Simulator 2002* comes in two versions: Standard and Professional. The Professional version includes extra aircraft, including a twin-engine Beech Baron, and also features gMax, a 3-D modeling tool for do-it-yourselfers interested in designing their own aircraft and scenery. Also new (Professional edition only) is a flight instructor station that runs on a second personal computer, enabling a student to be monitored and the instructor to control or alter various flight conditions.

Flight Simulator 2002 is a mind-bending achievement. At long last, Microsoft has delivered the product it promised when it came up with the slogan "As Real as It Gets." *Flight Simulator 2002* is the benchmark for all other flight simulations to follow.

—Tom LeCompte is a freelance writer and private pilot living in western Massachusetts.

CREDITS

No Way Out. In February 2001, Thomas D. Jones led three spacewalks on shuttle mission STS-98, helping to deliver and activate the U.S.-built laboratory Destiny at the International Space Station.

Son of Rocket Belt. Airline captain by day, writer by night, Vince Czaplyski prefers aircraft that have at least two engines and a full coffee pot.

The Birth of Spooky. Marshall Michel is the author of *The Eleven Days of Christmas: America's Last Vietnam Battle* (Encounter Books, December 2001). He wrote about that subject for the Dec. 2000/Jan. 2001 issue of *Air & Space/Smithsonian*.

The Lone Star Observatory. Eric Adams is an associate editor at *Air & Space*.

Shooting stars is nothing new for Washington, D.C.-based photographer Scott Suchman. He is a contract photographer for the John F. Kennedy Center for the Performing Arts and several other large Washington-area theaters and performance venues.

Probable Cause. Bill Adair covers aviation, national politics, and the U.S. Congress for the *St. Petersburg Times*.

How Things Work: Ejection Seats. Mary Collins is a consulting editor at *Air & Space*.

My First Time. As a boy, writer Phil Scott worshipped all famous astronauts and pilots. Finally he got to talk to them.

The Goodbye Guys. *Air & Space* contributing editor Beth Dickey wrote about cooperation on long missions in "How to Get Along in Space" for the Dec. 2000/Jan. 2001 issue.

A Price Too High. Mark Huber lives and flies in Michigan's Upper Peninsula.

Photographer Mark Godfrey covered the Vietnam War for Associated Press and later for *Life* magazine. A *Newsweek* assignment to the Oshkosh, Wisconsin fly-in in 1977 triggered his interest in aviation and led to a commercial pilot's license and the purchase of two airplanes and a glider. He has been happy, though somewhat poor, ever since.

The Man Who Could See Air. Peter Garrison is a frequent contributor to *Air & Space*. His last feature, "The Hammer," appeared in the Feb./Mar. 2001 issue.

"Now listen up you guys, I want you to welcome a new face in the squadron!"

CALENDAR

June 1
Aircraft Owners and Pilots Association Fly-In and Open House. AOPA Headquarters, Frederick Municipal Airport, MD, (301) 695-2162.

June 1 & 2
Bellanca-Champion Club West Coast Fly-In. Columbia Airport, CA, (510) 490-2865, *www.bellanca-championclub.com.*

Experimental Aircraft Association Family Flight and Balloon Festival. Helicopter flights, tethered hot-air balloon flights, vintage aircraft flybys, kite construction, and building and flying balsa gliders. EAA Aviation Center, Oshkosh, WI, (920) 426-6523, *www.flightfest.org.*

June 7–9
Mid-Atlantic Air Museum World War II Commemorative Weekend. Mid-Atlantic Air Museum, Reading Regional Airport, PA, (610) 372-7333.

June 15
"Ploesti: A Rembrance of War" Seminar. World War II's most tragic mission will be discussed by veterans of the 44th Bomb Group and 376th Bomb Group. American Airpower Heritage Museum, Commemorative Air Force Headquarters, Midland International Airport, Midland, TX, (915) 563-1000.

Virginia Aviation Museum Air Fair. Richmond International Airport, VA, (804) 236-3622.

June 29
Open Cockpit Day. Pueblo Weisbrod Aircraft Museum, Pueblo Memorial Airport, CO, (719) 948-9219.

July 6
Experimental Aircraft Association Chapter 690 Fly-In Pancake Breakfast and Airplane Wash. Gwinnett County Airport, Briscoe Field, Lawrenceville, GA, (770) 613-9501.

Nevada County AirFest. Nevada County Airport, Grass Valley, CA, (530) 273 1972, *www.nevadacountylife.com/airfest.*

July 14–20
International Deaf Pilots Association Fly-In. Frederick Municipal Airport, Frederick, MD, *www.deafpilots.com.*

July 26–28
Reunion: VR52/VR62 Detroit. Port Clinton, OH, (727) 862-6343.

Organizations wishing to have events published in Calendar should fax press releases two months in advance to (202) 275-1886 or mail them to Calendar, Air & Space/Smithsonian, *MRC 951, PO Box 37012, Washington, DC 20013-7012.*

FORECAST

In the Wings...

RICHARD VANDER MEULEN

Rounding pylons on a training flight, Curt Brown readies himself and his L-39 for the Reno races this September.

Jets at Reno

At this year's National Championship Air Races in Reno, Nevada, L-39 Aero Vodochody jets will be the new kids on the block. What will that do to the neighborhood?

Air War in the Falklands: 20 Years On

Some Argentines believed the British wouldn't bother with a clump of gray rocks half a world away. Then the Royal Navy showed up with a fleet of British Aerospace Sea Harriers.

Every Astronaut for Himself

A new concept for emergency exits from the International Space Station: Hop in your personal reentry capsule and come on down.

The Boneyard Biz

After September 11, lots of airliners were put out to pasture, and as they await a recall to service, they all need physical therapy.

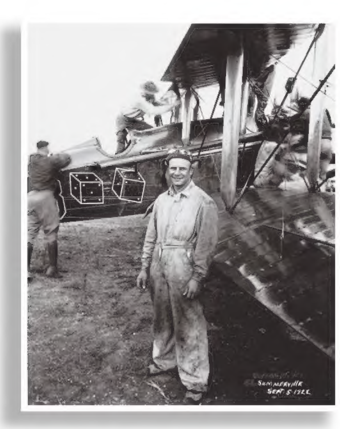
Space, Tourist Class

Today, a week on the International Space Station goes for $12 to $20 million; tomorrow, orbiting hotels will offer better deals.

ON THE WEB SITE

www.airspacemag.com

Planning to attend an airshow this summer? Please stop by the *Air & Space/Smithsonian* tent. In case our paths don't cross, we've included on the Web site an excerpt from our mini-exhibit "Great Moments in Aerobatics," which will travel to a number of this season's airshows.



NASM

Jimmy Doolittle, who performed the first outside loop, flew a de Havilland D.H.4 across the United States in 1922.

AIR & SPACE/SMITHSONIAN MAGAZINE IS NOW AVAILABLE ON AUDIO TAPE FOR MEMBERS WHO CANNOT READ STANDARD PRINT DUE TO DISABILITY. FOR THE BASIC MEMBERSHIP FEE, YOU WILL RECEIVE A PRINT COPY OF THE MAGAZINE PLUS THE AUDIO VERSION. IF YOU OR SOMEONE YOU KNOW HAS BEEN STRUGGLING WITH THE STANDARD PRINT VERSION BECAUSE OF VISION LOSS OR OTHER DISABILITIES, CONTACT THE SMITHSONIAN ACCESSIBILITY PROGRAM AT 1-888-783-0001 AND RECEIVE YOUR NEXT ISSUE OF AIR & SPACE ON TAPE.

50 and Counting

Stark images of bombs dropping on Afghanistan serve as an unhappy reminder of an otherwise celebratory event: the 50th anniversary of the introduction of Boeing's B-52 bomber.

For almost all of the last half-century, the B-52 has operated on the frontier of America's airborne defenses, beginning in the Cold War and followed by service in Vietnam, the Persian Gulf, Kosovo, and, most recently, the war on terrorism. In 2001 alone, the B-52 fleet accumulated over 23,000 hours, including 4,000 over Afghanistan.


USAF

Because bombers are most frequently flown at high altitudes (the B-52 can cruise at 50,000 feet), they rarely show up in the video footage aired on television news programs. Such aircraft are more familiar for the product they deliver. As the B-52's name, Stratofortress, suggests, these complex machines are cloud-hugging heavy-lifters. According to Boeing, "The B-52 is capable of dropping or launching the widest array of weapons in the U.S. inventory. This includes gravity bombs, cluster bombs, precision guided missiles, and joint direct attack munitions." With aerial refueling, the B-52 can carry approximately 70,000 pounds of weapons over distances "limited only by crew endurance."

One reason the B-52 has enjoyed such longevity—and is expected to remain in service at least another 25 years—is its ability to adapt to the changing needs of the military. Afghanistan vividly makes the case. For the war there, the B-52 has flown close-air support missions—a role normally assigned to fighters. This means the B-52 can launch precision-navigation devices against specific targets on the ground in response to instructions from troop commanders, a task very different from traditional bombing.

The Air Force refers to such evolving capabilities of its equipment as examples of "transformation" and promotes them as part of its strategy for waging war in the future. Retired Air Force General John Loh, who assumed command of the B-52 arsenal in 1992, says the B-52's performance in Afghanistan has made it "the poster child for the real meaning of transformation…in military affairs."

The B-52's birthday is April 15, 1952, the day Boeing first flew a prototype. Boeing celebrated the occasion last April with ceremonies at its Wichita, Kansas plant, where the aircraft was last built. Before closing the B-52 assembly line in 1962, Boeing produced 744 Stratofortresses in eight models, A through H.

It takes only five people to fly such a big warhorse: a commander, pilot, radar navigator, navigator, and electronic warfare officer. Over the years, the crews of the B-52 adopted, as aviators are wont to do, a nickname that translates to something like Big Ugly Fat Fellow. Happy Birthday, BUFF.

—Stuart Nixon

Moments & Milestones is produced in association with the National Aeronautic Association. Visit the NAA Web site at www.naa-usa.org or call (703) 527-0226.

LOGBOOK

Awards

One of aviation's oldest organizations, the Ninety-Nines, formed in 1929 of the 99 women pilots who turned up for the first meeting, was chosen to receive the National Aeronautic Association's Frank G. Brewer Trophy. The trophy, which recognizes excellence in aerospace education, was presented at the NAA's annual spring award reception last April 4, co-hosted by the Civil Air Patrol and sponsored by TRW, Inc.

A unique vertical-lift system that will power one variant of the U.S. military's new Joint Strike Fighter (JSF) was selected as the winner of the 2001 Robert J. Collier Trophy. Pratt & Whitney led the team that developed the system. The trophy was presented to the industry team at a ceremony in Washington, D.C., last May 29.

Nominations

Through July 31, 2002, nominations will be accepted for the Katherine and Marjorie Stinson Award for Achievement, which is presented annually for an outstanding and enduring contribution, a meritorious flight, or a singular technical development in the field of aviation, aeronautics, space, or related sciences.

Nominations for the Wright Brothers Memorial Trophy, which is awarded annually "to a living individual for significant public service of enduring value, as a civilian, to aviation in the United States," will be accepted through June 30, 2002.

Events

15th World Precision Flying Championship, Lucko Airport, Croatia, July 7–14. *www.caf.hr/news/15_wpfc_eng.htm*

World Aeromodelling Championship, Tillsonburg, Ontario, Canada, July 12–21.

2002 Advanced World Aerobatics Championship, Sobota, Slovenia, Aug. 2–12. *www.aeroklub-ms.si*